non linear systems, inc.

DEL MAR, CALIFORNIA

MODIFICATION DATA

MODEL 1207

AC - DC CONVERTER

The Model 1207 AC - DC Converter differs from the Series 1200 Converters, described in this manual, in the following respects:

1. The Model 1207 includes a time delay circuitry (See Drawing No. 1363) to inhibit the associated Digital Voltmeter from issuing a print pulse until the converter has reached a stable output.

2. The Model 1207 has been modified to minimize voltage transients applied to the input leads. See Note No. 7 of Drawing No. 12-12.

3. The Model 1207 has a special control cable. See Drawing No. 15004-500.

4. In operation, the black and blue clips of the input cable (pins B and C) must always be connected together.

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INSTRUCTION MANUAL
SERIES 1200 (MODEL 125)
AC TO DC CONVERTERS

MODEL NUMBER CHANGE:

The designations of Models 125B (part no. 18089), 125C (part no. 18072), and 125E (part no. 18053) have been changed to Models 1201, 1202 and 1203, respectively. Characteristics have not been changed.

APPLICABILITY:

This manual pertains to all the above models and to Model 1204. The models are essentially the same, except that the 1201 and 1202 do not have the transistor circuits that give the 1203 automatic ranging. The 1202 ranges are selected by remote signals from the AC range switch in the associated NLS digital voltmeter. The 1201 ranges are selected by a manual switch on the 1201 front panel. The Model 1204 AC to DC converter is also essentially similar to these models, except that ranges can be selected both manually and automatically, and front panel lamps indicate range in use.

This manual is for instrument Serial No._____

Non-Linear Systems, Inc.
Del Mar, California

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INTRODUCTION

1.1 The Series 125

The NLS Series 125 AC to DC Converters allow NLS manufactured digital voltmeters to be used with alternating current input signals.

This input accessory is supplied in several versions so as to meet a number of user requirements. The basic instrument in the series is designated 125E; this accessory converter is designed to shift ranges automatically, manually, or remotely. The other converters in the series are designated 125B and 125C; these converters are manually ranged.

In addition, the basic 125E instrument is also available with other options; for example, the Model 125ER is equipped with a modified output so as to drive a reference input to the NLS 20 and 30 Series Digital Voltmeters for AC ratio use. There is also a Model 125ET automatic ranging instrument with built-in time delay. These latter two instruments, the 125ER and 125ET, are described in documents which, if needed, accompany this manual.

Since the basic instrument in the series is the 125E, the manual is primarily oriented toward the one instrument. The differences which exist among the three instruments are discussed in the remainder of this section. In addition, the parts list correctly identifies the components of each instrument in the series. Schematic diagrams of the 125B, 125C and 125E are at the end of the manual.

1.2 Model 125B (part number 18069)

The 125B is a simplified, manual-ranging version of the 125E and is suitable for use with any NLS digital voltmeter having a 10 megohm input impedance and a measuring range from 1 mv. to 9.999 volts. The following NLS digital voltmeters are compatible with the 125B:

V64A, 481A, 484, V35, V35A, V34, V34A	All use converter output cable 15004-129 and DC input cable 15004-126.
M24	Uses 15004-128 input cable and 15004-075 output cable.

The 125B specifications are the same as for the 125E as listed in Section 2 of this manual. However, neither automatic ranging nor remote operation are provided. Since the 125B is manually ranged, a front-panel multiplier switch is used for range selection. The instrument will operate at maximum accuracy in its 10-volt (9.999) range. If the digital voltmeter used with the converter has a manual DC range switch, it should be locked in the 10-volt position; the AC position is used on digital voltmeters so equipped. In any case, the output of the converter should not be allowed to exceed 9.999 volts; this can be controlled by manipulating the converter front-panel switch. The remaining sections of this manual are wholly applicable except as noted in this section.

1.3 Model 125C (part number 18072)

The 125C is a remotely ranged version of the 125E Converter and is compatible with any NLS digital voltmeter having a 10-megohm input impedance and a measuring range from 1 mv. to 9.999 volts. Thus, the 125C may be used with NLS Models V35, V35A, V34, V34A, and M24. The cabling connections are made with the same cables listed for the Model 125B (Section 1.2) except that an added interconnecting cable, 15004-076, is needed to provide digital-voltmeter-switched power and remote ranging connections.

The 125C Converter will lock to the range set on the associated digital voltmeter. However, maximum accuracy is obtained by operating the digital voltmeter in its 10-volt (9.999) range. The AC setting on the digital voltmeter is used for all AC readings. To avoid exceeding the 9.999-volt limit of the converter, attenuators are provided which are controlled by the digital voltmeter RANGE switch. In this way, it is possible to read up to 1000 volts.

The NLS Engineering Department will be glad to help you with specific application problems. A call or letter to our office in your area, as listed in the *Appendix*, or to the home office, will receive prompt attention.

SPECIFICATIONS

Input Voltage Ranges:

10/100/1000 volts AC. These ranges are selected:

1. Automatically,
2. Manually, by a switch on the digital voltmeter, or
3. Remotely, through contact closures.

Input Impedance:

10 megohms and 40 uuf shunt capacitance.

Output Voltage:

10 volts DC for 10, 100, or 1000 volts AC input (governed by the input voltage range in use) when connected to the 10-megohm input load of an NLS digital voltmeter.

Compatibility with NLS Digital Voltmeters:

The 125E Converter may be connected without wiring changes to the NLS Models V34A, V35A. The converter is also compatible with the Models V24 and M24 having serial number 10.700 or larger.

If the 125E is to be used with other instruments, or with earlier versions of the M24 and V24, consult an NLS representative or the factory for wiring changes.

Frequency Range:

30 cps to 10 kilocycles.

Accuracy of AC-to-DC Conversion (% of Full Scale on Each Range):

0.1% of reading, plus one digit.

Calibration:

The 125E is calibrated in terms of the RMS value of a pure sine wave. The converter output voltage is proportional to the average value of the input voltage.

Balancing Time:

3 seconds, average.

Connections:

Signal input and signal output grounds are common, but are not connected directly to the converter's chassis within the converter. The converter's chassis and digital voltmeter chassis are common when the two instruments are connected. Type MS3102A connectors on the rear panel are used – one each for the input and output.

Power Source:

115 VAC, 60 cycles; power consumption is 70 watts. No power cord is used; the 125E converter draws its power through cabling to the digital voltmeter. The digital voltmeter power switch is wired ahead of the converter power take-off so that the converter works in unison with the digital voltmeter.

Dimensions:

The 125E mounts in a standard 19″ wide rack, is 3½″ high and 15¼″ deep.

Weight:

Net: 27 lbs., shipping: 45 lbs.

NOTES:

1. Except as noted in the Introduction, the above specifications are applicable to all standard NLS 125 and 1200 Series Converters.

2. As of approximately November 1964, the standard Models 1201, 1202, 1203 and 1204 AC to DC converters have an over-all accuracy of ±(0.1% of reading + 0.01% of full scale of range in use). The converter output voltage reaches 0.01% of final value in 8 seconds for a full scale step input within any range. See page 8 for clarification and recent specification changes.

Digital voltmeter models' numbers have been changed, and numbers equivalent to those mentioned above, under compatibility, are as follows (with new designations shown in parentheses):

V34A (34B or Series 3000), V35A (V35B or Series 3000).

M24 (Model 2019 or Series 2000), V24 (Series 2000).

Construction And Circuit Features

- Wide range, high input impedance, and high accuracy.
- Circuitry proven by five years use with NLS digital voltmeters.
- Highest quality construction on epoxy-fiberglass circuit boards.
- Available with automatic, manual or remote range selection.
- Automatic range selection is quickly and reliably performed by an internal, transistorized, voltage comparator which is completely independent of digital voltmeter logic circuits.

SPECIFICATIONS

See next page for type of ranging and remote control for each model in this series.

Voltage Ranges: 9.999/99.99/999.9 volts.

Frequency Range: 30 cps to 10 kc.

Range Selection: Automatic (A), manual (M), or remote (R), depending upon model. In compatible models, 1202 and 1203 ranges are selected by remote signals originating from manual switch on associated dvm (also automatically in 125E), and dvm readout decimal point tracks the range data. In 1204 only, front panel lamps indicate range is in use.

Input Impedance: 10 megs shunted by 100 pf.

Output Voltage: 10 volts dc for 10, 100 or 1000 volts input (governed by range selected) when output is loaded by 10 megohm NLS dvm input circuit. Converters are generally within specification up to 11.5 v. output so ratio of 115 v. ac signals can be measured on 100 v. range.

Accuracy of AC to DC Conversion: ±(0.1% of reading + 0.01% of full scale of range in use.

Calibration: Is in terms of RMS value of a pure sine wave. Converter output is proportional to average value of input voltage.

Balancing Time: 3 sec., avg. Output achieves 0.01% final value in 8 sec., max., for full scale step input on any one range.

Input Connections: Connect input to be measured, whether ac or dc, to converter input. When switched to dc function, converter circuits are by-passed and unknown input signal is applied direct to dvm input. Input and output connectors are on both front and rear panels of Model 1201 and on rear panel only in all other models.

Ground Isolation: Inputs are isolated from converter chassis, but become connected to dvm input ground. For complete ground isolation, use of a precision transformer for input signal is recommended.

Dimensions: 3½" high, 15¼" deep, 19" wide, for bench tap or rack use.

Note: Specifications and prices are subject to change without notice.

AC Voltage Ratio Measurement: To measure ac voltage ratio, two ac to dc converters must be used, one to convert the ac input voltage to dc and the other to convert the ac reference voltage to dc. Then, the ratio of the two resulting dc voltages are measured with an NLS dc digital voltmeter (ratiometer). For ac voltage reference conversion, the Model 1205 is used since it can drive the relatively low resistance (20 to 50 kilohms) reference input of dc digital voltmeters (NLS Series 1100 Converter can also be used as a reference converter). Input waveshape normally has no effect upon ratio measurements as long as input and reference signal waveshapes are identical. For full accuracy, reference converter dc output voltage must be within limits specified in the dc digital voltmeter specification (generally, 10 volts dc; as low as 1 volt for 4 digit Series 2000, 3000 and 3100 dvms).

Compatability: These converter-digital voltmeter combinations are practicable (if other combinations are required, please consult NLS):
Model 1201 with Series 2900, 4300, 4600, 4700, 4800, 4900, 7000, 9100
Model 1202 with Series 2000, 3000, 3100, 4400
Model 1203 with Series 2000, 3000, 3100
Model 1204 with Series 2900, 3200, 4300, 4400, 4600, 4700, 4800, 9100
Series 1100 Converters can be built into 4900 Series dvms, but 1201 and 1204 can be used externally.
Model 1205 with any NLS digital voltmeter that measures dc voltage ratio.
Note: Models 1201, 1202, 1203 and 1204 operate to full specified performance only in conjunction with the NLS digital voltmeter's 10 volt range (100 v. range in 5 digit Series 2000, 3000 and 3100) and a 10 megohm input impedance. For example, a digital voltmeter having a fixed range of 1000 v. or 1 v. is normally incompatible. If the dvm has 1000 megohm input impedance, a 10 meg load resistor must be added. The dvm can, however, have fixed polarity (+ only).
Since Series 1200 output noise exceeds .001%, 5 digit dvm readings may "jitter." In 5 digit ac-dc models, NLS reduces dvm resolution to .01% (4 digits) on ac.

Weight: Approx. 19 lbs., net, 40 lbs. shipping.

Primary Power: 115 v., 50-60 cps. Transformer tap is provided for 220 v. operation.

Originator of the Digital Voltmeter
non-linear systems, inc.
DEL MAR, CALIFORNIA

Section 3

INSTALLATION AND OPERATION

3.1 Operating Environment

The 125E Converter may be mounted in a rack with associated equipment or it may be used as a bench instrument. Care should be taken to assure proper ventilation. Allow space for the blower exhaust at the rear as well as at the sides for air intake. Operation near strong electrical fields, as occur at radio transmitters and other radio-frequency equipment, should be avoided unless elaborate steps for electrical shielding have been taken. Stray high-frequency signals can be a source of spurious readings on the digital voltmeter. Since the converter uses mercury-wetted relays, it should not be tilted more than 30 degrees from the horizontal. Environmental conditions which are suitable for a digital voltmeter will suffice for the 125E Converter.

3.2 Connection Procedures

1. Connect the 34-pin connector (J-13) on the converter to the AC converter connector on the rear panel of the DC digital voltmeter by using the cable furnished with the converter. Figure 3-1 shows typical cables and Figure 3-2 identifies cabling connections.

2. Connect the converter's DC output (connector J-12) to the input terminal of the DC digital voltmeter by using the harness furnished with the converter. With Series 20 digital voltmeters, cable 15004-128 is used; with Series 30 instruments, the 15004-129 cable is used.

3. Connect the AC or DC input signal to J-11 at the rear of the converter. See Figure 3-3.

Pin A	Input high side
Pin B	Input low side
Pin C	Carries chassis ground of digital voltmeter and converter through converter to input.

NOTE

When measuring AC voltages, Pins B and C should normally be shorted together. If any AC voltage exists between Pins B and C, converter accuracy will suffer.

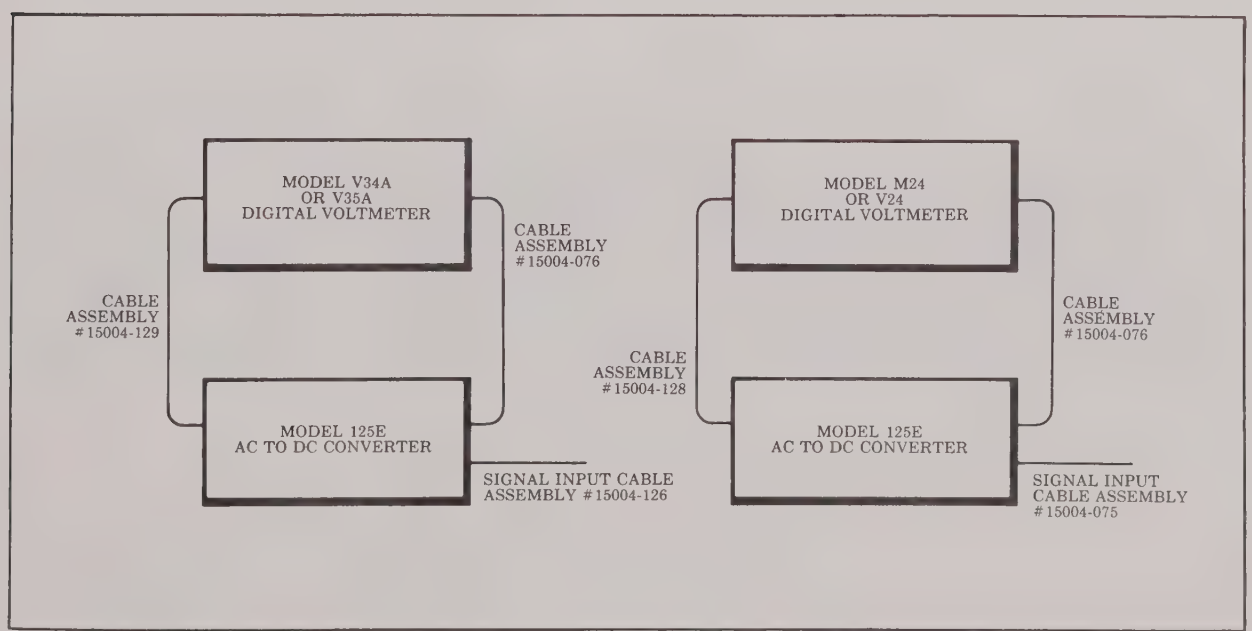


Figure 3-1. Cables Supplied with Converter.

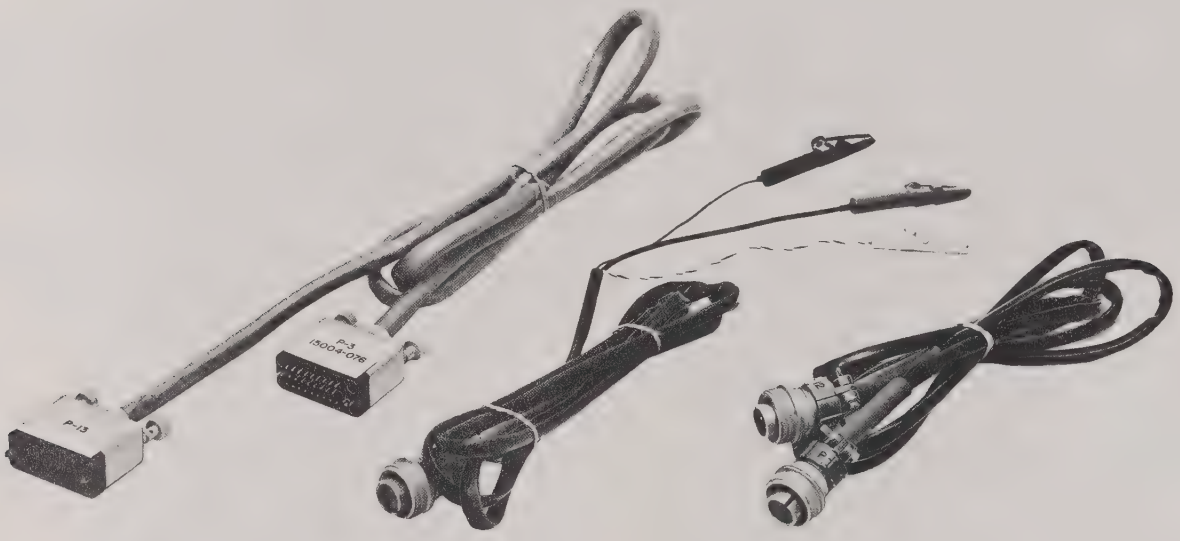


Figure 3-2. Cable Assemblies by Part Number.

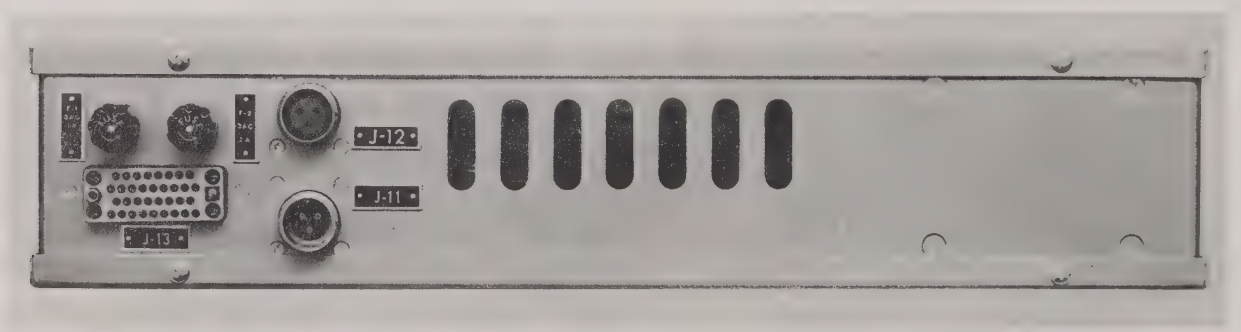


Figure 3-3. Converter, Rear View.

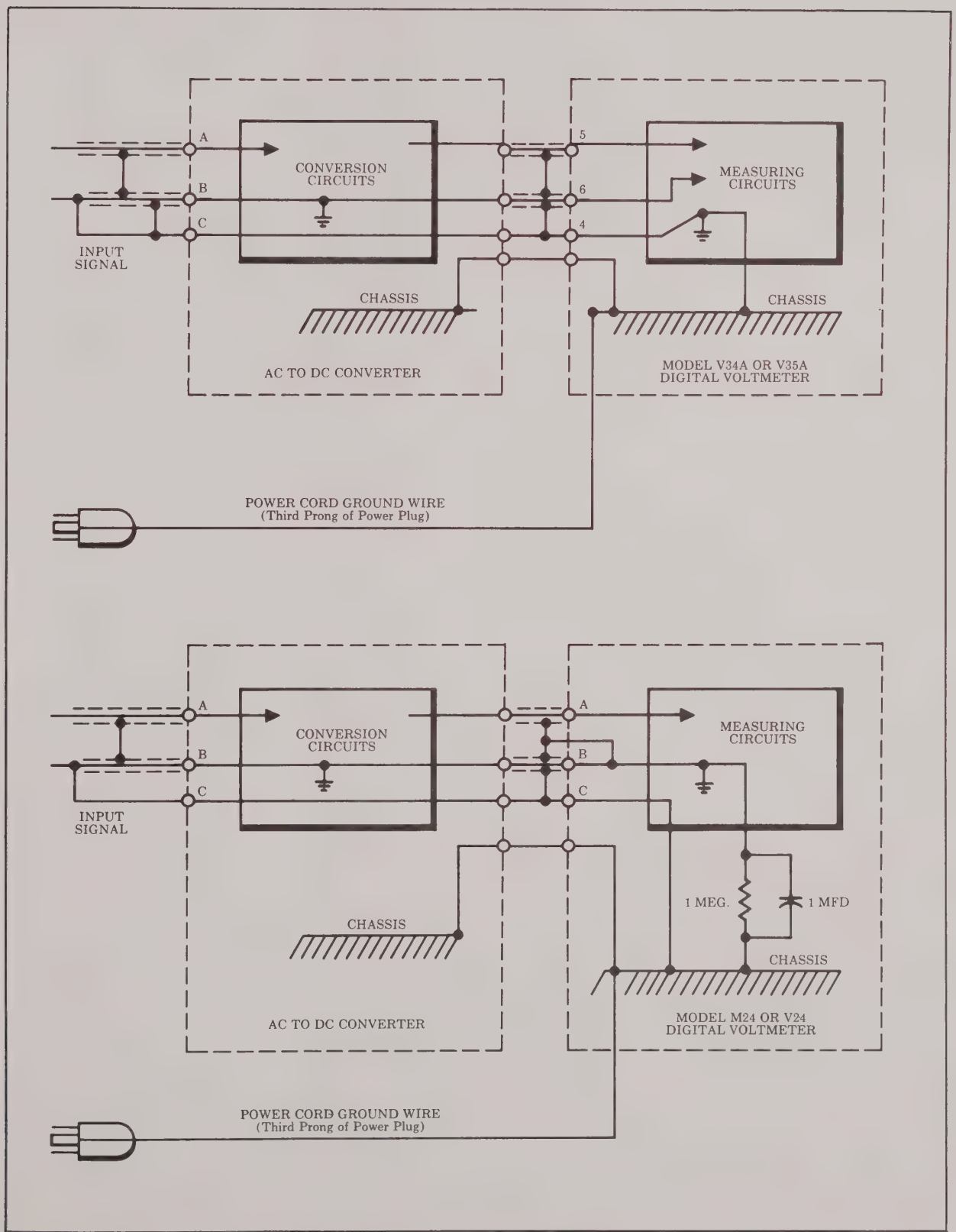


Figure 3-4. Ground Circuits.

On AC ranges, the digital voltmeter's selector switch connects the input signal to the AC-DC conversion circuits. On DC ranges, the selector switch connects the input signal directly to the converter's DC output (connector J-12). Remember that test lead capacitance can cause appreciable loading of signal circuits, especially at high frequencies. See Figure 3-4.

CAUTION

Chassis ground and signal ground are not connected together in the converter, but they are connected together through the digital voltmeter. Fuse F-2 protects the wiring against burnout if a "hot" lead is connected to the signal ground terminal.

Where completely ground isolated AC signal connections are required, use an external input transformer for the signal circuits. Important factors in transformer selection include frequency response characteristics, primary impedance, turns ratio accuracy, and adequate shielding to prevent noise pickup. Primary impedance is important only because of the effect that a low primary impedance might have upon the output voltage of the circuits being measured. Frequency response characteristics and turns ratio accuracy are important because of the effect they have on overall measurement accuracy.

4. Set the range selector switch on the digital voltmeter's front panel to AUTO VAC on the range of expected use for AC signals or to the DC position when measuring DC signals.

5. Turn on the 115-volt AC power.

6. The digital voltmeter readout decimal point location is controlled by the range selector switch or by the automatic range selection circuitry in the converter.

7. For remote selection of AC voltage range and AC or DC measurements, refer to the drawings provided with the digital voltmeter associated with the converter.

CAUTION

Do not connect more than 1000 volts to the converter input. Full accuracy is only obtained with inputs no higher than 10 volts on the 10 volt range, 100 volts on the 100 volt range, and 1000 volts on the 1000 volt range.

CALIBRATION

4.1 General Procedure

To calibrate the converter, connect the equipment as shown in Figure 4-1; sweep the AC voltage source over the converter's frequency and voltage range or over the range required in your application, and compare the digital voltmeter's readings to readings on the standard AC voltage measuring instrument. The two sets of readings should agree after the composite error of several factors has been weighed. Consider the following possible errors:

1. Total error of the converter,
2. Error of the DC digital voltmeter,
3. Error of the standard AC voltage measuring instrument, and
4. Error due to harmonic distortion in the AC voltage source.

If, after considering the areas in which error may occur, the converter is not within tolerance, follow the balance of this section to readjust the instrument.

4.2 Precautions

Before calibrating, observe the following:

1. Load the converter's output only with a digital voltmeter having a 10-megohm input impedance. The converter has a high output impedance and small changes in load can affect its DC voltage output appreciably.

2. Calibration signal source must be very stable.

3. The calibration signal source wave form must be sinusoidal with low harmonic content to minimize inaccuracies caused by harmonic distortion. Remember, the converter is designed for measuring sinusoidal voltages; its reading is proportional to the average value of the input wave form and the instrument is calibrated at the factory to indicate the RMS value of a pure sine wave. If the signal wave form is not a pure sinusoid, do not expect the converter to agree with an AC instrument which measures the wave-form RMS value (thermal converters, dynamometer-type voltmeters, etc.). Differences between AC measurements made with the converter and the true RMS values of non-sinusoidal wave forms depend upon relative magnitudes and phase relationships between the fundamental and the harmonics which are present.

The following table shows the maximum differences that can exist between the measurements made with the average sensing converter and the true RMS value of the wave form being measured. Actual differences may be much less than the maximum shown in the table depending upon phase relationships between fundamental and existing harmonics.

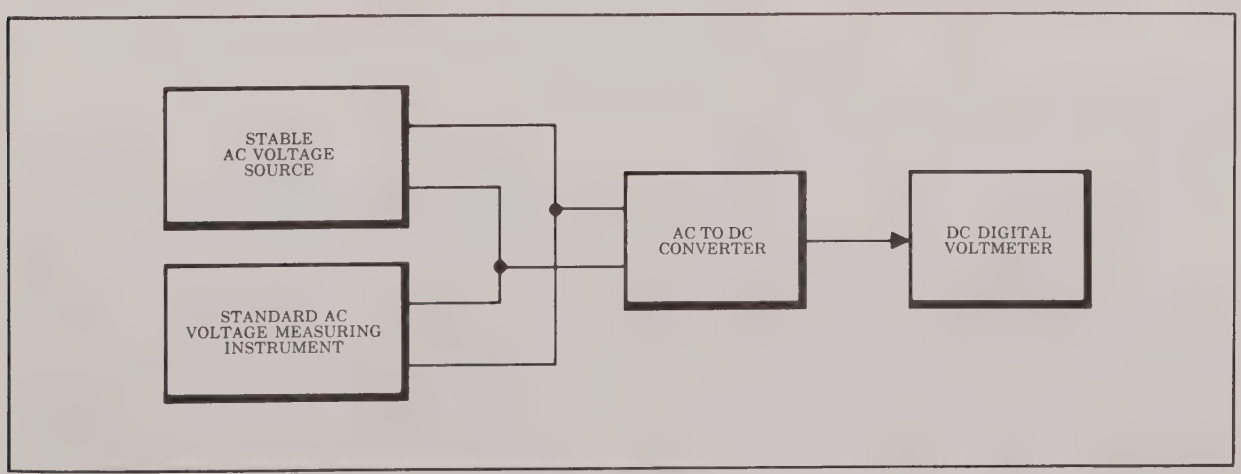


Figure 4-1. Flow Diagram for Calibration Setup.

Second Harmonic	
Percent Harmonic	Maximum Error Expected
10%	0.5%
20%	2 %
50%	12 %

Third Harmonic	
0.3%	0.1 %
0.5%	0.17%
1 %	0.35%
5 %	1.7 %
10 %	4.5 %
20 %	8 %
50 %	22 %

4. Before calibrating the converter, the associated DC digital voltmeter must be within its specified accuracy tolerance.

5. Use shielded leads and a good ground to prevent noise pick-up problems.

6. One input terminal of the converter is connected to the digital voltmeter chassis, except in Series 20 instruments carrying part numbers below 10.700. Do not apply a potential between the "low" signal input terminal and chassis. A fuse has been provided to prevent damage to the wiring if this sort of connection is attempted.

7. For the best results, permit the converter to warm up for thirty minutes before adjusting its calibration controls.

8. Any voltage dividers used in the calibration procedure must be frequency compensated. At high frequencies, test wiring capacitances and converter input capacitance can cause appreciable loading; therefore, test leads should be as short as possible.

9. As with most measuring instruments, calibration is more accurate when performed near the top of each voltage range.

10. The adjustment procedure in Section 4.3 mentions frequencies of "30 to 100 cps" and "10 kc." Other frequencies between 30 cps and 10 kc can be used if these frequencies are not available. For example, 400 cps can be used for low frequency adjustments and 5 kc may be used for high frequency adjustments; the possibility of error below 400 cps and above 5 kc must be accepted. If your application requires use at a single frequency, maximum accuracy will be obtained if calibration is made at that one frequency.

11. The time required for calibration will be much shorter if the readings obtained after each step given in Section 4.3 are plotted on graph paper. Then, the effect of each control will be readily apparent. After reviewing the graph, the controls can be more satisfactorily adjusted to bring the converter into tolerance by, for example, causing an intentional error in one direction at a certain frequency so as to cause the curve of frequency versus error to come within tolerance at other frequencies. Another reason why the plotted readings are helpful is that frequency compensation controls have a much greater effect at higher frequencies than at lower frequencies. Figure 4-2 plots error versus frequency for a typical converter after calibration.

12. During the calibration procedure, the top and bottom covers of the converter should be in place. However, the front panel is removed to provide access to these controls. The front panel may be removed by detaching the handles. Adjustment controls are labeled on the inside panel as shown in Figure 4-3.

4.3 Adjustment Procedure

In the procedure steps which follow, the phrases "for agreement" or "to achieve agreement" mean *to bring the digital voltmeter reading within the accuracy tolerance required.*

1. Switch the digital voltmeter to bring the converter to the 10-volt range.

2. With an input voltage slightly less than 10 volts, at a frequency between 30 and 100 cps, adjust R-2 (labeled LOW FREQUENCY ADJUSTMENT, 10 V) for agreement.

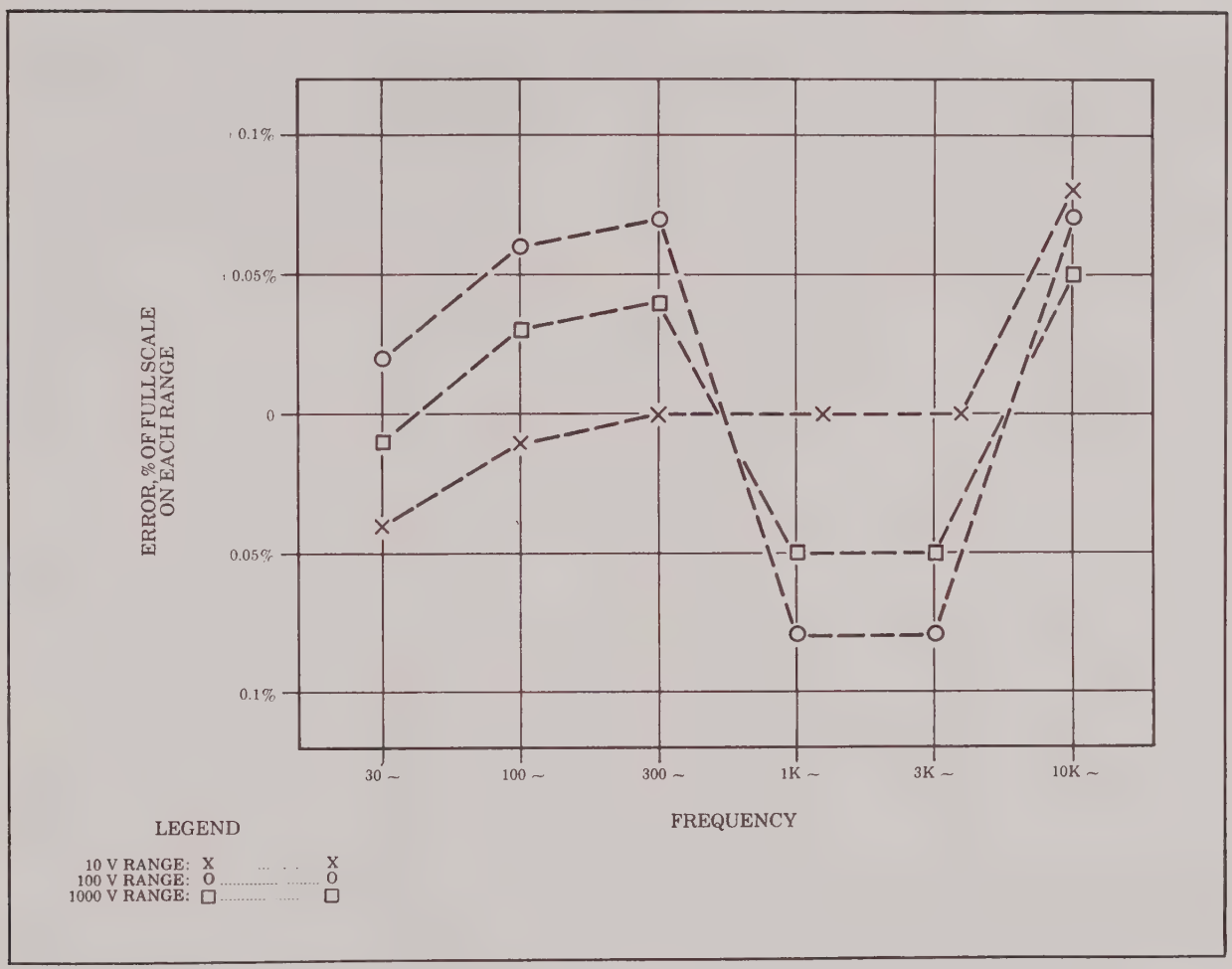


Figure 4-2. Typical Plot of Error vs Frequency after Calibration.

3. Switch the digital voltmeter to bring the converter to the 100-volt range.

4. With an input slightly less than 100 volts at a frequency between 30 and 100 cps, adjust R-3 (labeled LOW FREQUENCY ADJUSTMENT, 100 v) for agreement.

5. With an input voltage slightly less than 100 volts, and at a frequency of 10 kc, adjust C-1 (HIGH FREQUENCY ADJUSTMENT, 100 v) for agreement.

6. Repeat Step 4 and readjust R-3 (LOW FREQUENCY ADJUSTMENT, 100 v) if needed to achieve agreement. If R-3 has required readjustment, repeat Step 5. It may be necessary to repeat Steps 4 and 5 several times to achieve agreement at low and high frequencies. The adjustment of R-3 and C-1 can be readily achieved if it is realized that R-3 affects both the low and high frequency calibration, while C-1 affects mostly the high frequency calibration.

7. With an input voltage of at least several hundred volts and at a frequency of between 30 and 100 cps, adjust R-4 (LOW FREQUENCY ADJUSTMENT, 1000 V) for agreement.

8. With an input voltage of several hundred volts at 10 kc, adjust C-2 (HIGH FREQUENCY ADJUSTMENT, 1000 V) for agreement.

9. Repeat Step 7 and readjust R-4 (LOW FREQUENCY ADJUSTMENT, 100 V) if needed to achieve agreement. If R-4 requires readjustment, repeat Step 8. It may be necessary to repeat Steps 7 and 8 several times to achieve agreement at low and high frequencies. The adjustment of R-4 and C-2 can be achieved more readily if it is recognized that R-4 affects both the low and high frequency calibration while C-2 affects mostly the high frequency calibration.

10. C-1 and C-2 slightly interact if either one requires a large change during calibration. Repeat Steps 4 and 5 to check interaction. All ranges of the instrument are now in calibration. The remaining steps in the adjustment procedure apply to the automatic range changing circuitry only.

11. In converters having automatic ranging, rotate R-5 and R-6 counterclockwise, and R-7 and R-8 clockwise until their stops are reached.

NOTE

The potentiometers require 43 turns to travel from stop to stop.

12. Switch digital voltmeter to bring the converter into the AUTO VAC mode, and apply 9.900 V to the input of the converter. The dvm should read 9.900 V ±0.010.

13. Rotate R-7 counterclockwise until the converter up-ranges, and the dvm will read 09.90 V ±00.10.

14. Decrease input voltage till the dvm reads 09.40 V.

15. Rotate R-5 clockwise until the converter down-ranges. The reading will then be 9.400 ±0.010.

16. With 99.00 V into the converter, the dvm should read 99.00 ±00.10.

17. Rotate R-8 counterclockwise until the converter up-ranges. The dvm reading will be 099.0 ±000.2 V.

18. Decrease the input voltage until the dvm reads 094.0 V.

19. Rotate R-6 clockwise until the converter down-ranges. The dvm reading will then be 94.00 ±00.10 V. The converter is now calibrated, and automatic ranging circuits have been adjusted.

20. Repeat input voltage changes of steps 12 to 19 (without rotating the adjustments) to recheck operation of the automatic range changing circuits.

Figure 4-3. Location of Calibration Controls made Accessible by Removal of Front Panel.

Section 5

THEORY OF OPERATION

In the Model 125E Converter, semi-conductor diodes are used to convert the unknown AC input into pulsating DC. This DC is then filtered to obtain a very pure DC voltage proportional to the average value of the AC input wave form. A high-gain feedback system linearizes and stabilizes the rectification characteristics of the diodes. To best understand the operation of the Model 125E Converter, Figure 5-1, Signal Flow Diagram, and the main foldout schematic at the rear of the manual should be consulted.

The converter input attenuator (range unit) attenuates the unknown AC input by precisely 10:1 or 100:1, as required to restrict the conversion circuit input to 10 volts, maximum, for full scale inputs of 100 volts and 1000 volts, respectively. C-1 and C-2 provide frequency compensation adjustment in the attenuator on the 100-volt and 1000-volt ranges, respectively.

The attenuator output is fed into a high-input impedance-isolation amplifier, V-2A, and

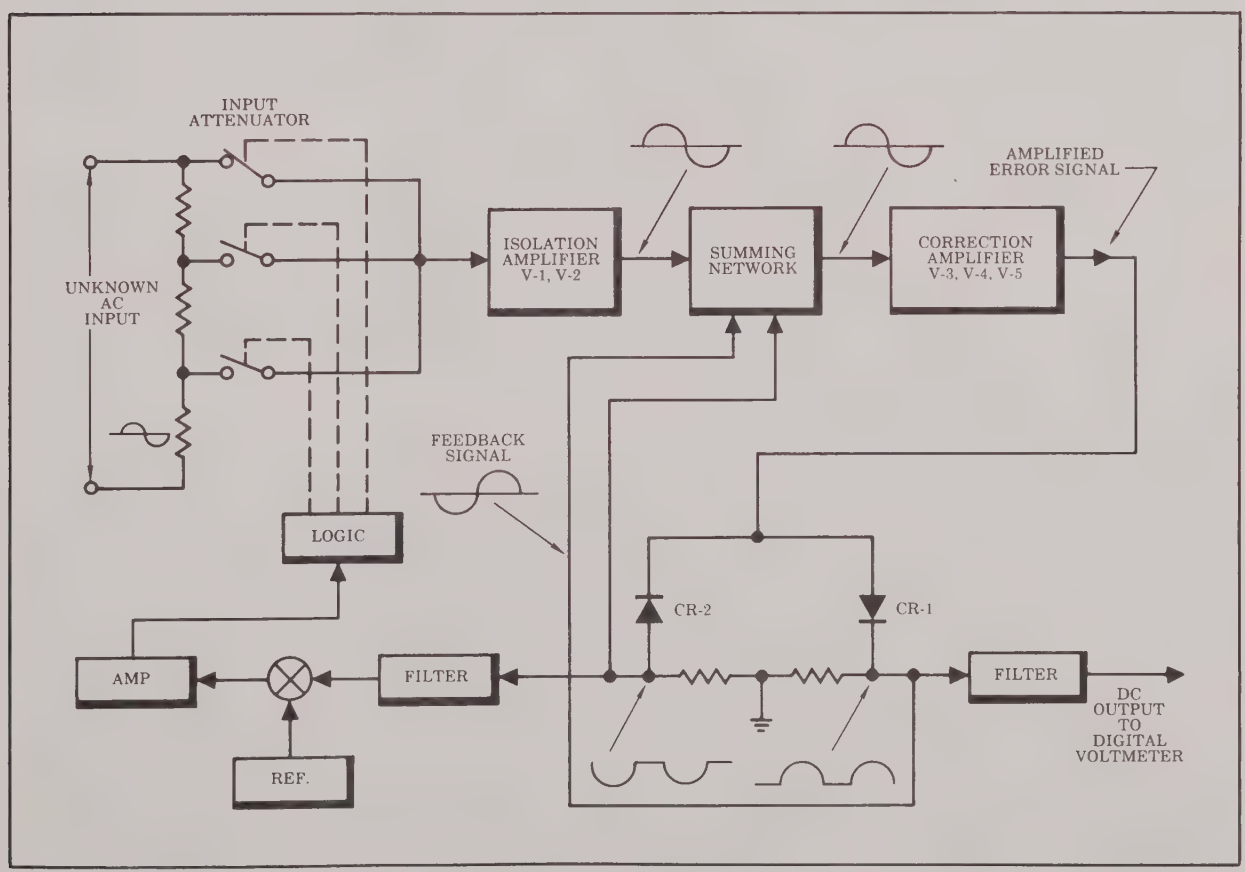


Figure 5-1. Signal Flow Diagram.

V-2B, which prevents the summing network R-18, R-19, R-20, R-21, and C-15 from loading the input attenuator.

The summing network sums the isolation amplifier output with a 180° out-of-phase feedback voltage derived from the converter output stage. The summing network output is amplified by the high gain amplifier V-6, V-7, and V-8, and rectified by diodes CR-13 and CR-14. The half-wave output of CR-13 is filtered and forms the DC output of the converter. The feedback signal is obtained by mixing the half-wave outputs of CR-13 and CR-14. R-2, R-3, and R-138 form adjustable output voltage dividers which permit adjusting the scale factor on each range. Relays K-1 and K-2 operate when selecting a mode of operation (AC measurements or DC measurements); K-3, K-4, K-5, and K-6 operate when selecting the AC voltage range. An internal 28-volt DC supply furnishes power for relays in the converter.

The output of the second filter operating from a half-wave output of CR-14 is compared with a DC reference by chopper K-7 and amplifier Q-3. The output of Q-3 controls the transistor logic circuits. The output of the logic circuit is allowed to control range relays K-3, K-4, K-5, and K-6 when the converter is operating in the automatic mode.

MAINTENANCE AND TROUBLESHOOTING

Trouble-shooting is much easier once the user has become completely familiar with the operation and theory of the instrument as described elsewhere in this manual.

The first general step in correcting any trouble which may develop in the converter is to isolate the malfunctioning section or sections of the circuit. The trouble-shooting tables and tube socket voltage charts at the end of this section will help to localize the area of breakdown. In addition, systematic signal tracing can locate troubles not mentioned in the charts. Additional maintenance help is available through the N.L.S. representative in your area, or directly from the home office of Non-Linear Systems, Inc.

6.1 Test Equipment

The only test equipment required for maintenance of the converter are an oscillator, a vacuum tube voltmeter, and an oscilloscope. Special equipment needed for calibrating the converter is discussed elsewhere in the manual.

6.2 Spare Parts

Most electronic parts used in the converter are standard, commercially available items. A parts list along with a separate spare parts list is included in this manual. If unlisted mechanical parts are needed, contact the home office of Non-Linear Systems, Inc., or a regional sales and service representative.

6.3 Signal Tracing

This section gives information to aid in tracing signals through the converter. Refer to Figure 5-1, Signal Flow Diagram, and the converter's schematic for additional information. Most voltage measurements are made with respect to signal ground.

1. Setup:

Connect a stable AC voltage to the converter's input terminals. Follow the instructions given in Section 3, Installation and Operation. The AC voltage should be slightly under 10 volts to avoid saturation, unless trouble is evidenced on the higher ranges.

2. Input attenuator:

The input attenuator output can be measured at Pin 2 of V-2. However, loading effects present so great a problem that measuring the attenuator's output voltage is generally of little help in trouble shooting.

CAUTION

Do not bend the wires which interconnect the range attenuator components. Attenuator wiring capacitances are very critical and the calibration will be affected by capacitance changes.

3. Isolation amplifier:

The output of the converter's isolation amplifier is measured at Pin 3 of V-2. As an accurate unity gain amplifier, its output voltage should be equal to its input voltage to within 0.2%. If it will help isolate trouble, disconnect the unity gain amplifier and drive the remainder of the converter from an AC signal source. This disconnection may be made by simply unsoldering the lead which connects C-15 to Pin 3 of V-2. Connect the AC input signal to the unsoldered end of C-15.

4. Correction Amplifier:

The correction amplifier is best tested by measuring the error signal at Pin 1 of V-7. The error voltage is normally 40 millivolts, maximum. A large error signal usually indicates absence of feedback voltage. Feedback voltage is developed by the correction amplifier output at Pin 7 of V-6, then through C-26, CR-13, CR-14,

R-20, and R-21. The summing network, which consists of R-18 and R-19, sums the isolation amplifier output and CR-13 and CR-14 output to form an input (error signal) for the correction amplifier.

5. Conversion Diodes:

When a 10-volt RMS sine wave is applied to the converter's input terminals, the voltage from the junction of CR-13 and R-20 to ground and the voltage from the junction of CR-14 and R-21 to ground should be approximately 22 volts, peak. The wave form at each of these junctions should be a half-wave rectified sine wave. Use a low capacitance probe when measuring CR-13 and CR-14 output.

6. Output Filter:

The output filter (R-22, R-23, R-24, C-9, and C-15, and C-16) filters the half-wave output

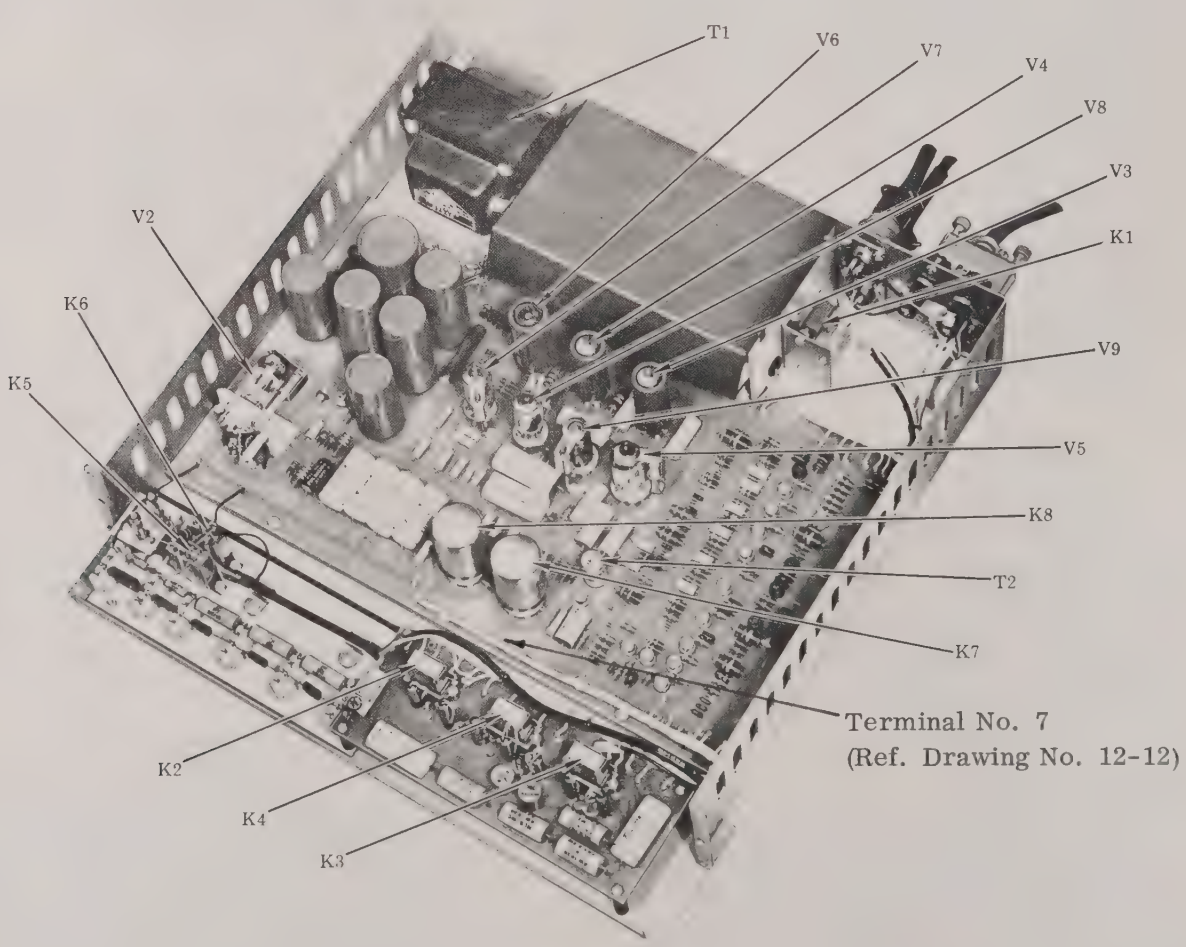


Figure 6-1. Top View of Converter with Front Panel Dropped to Reveal Ranging Components.

of CR-13 to form the pure positive DC output signal. The filter's time constant is relatively long since it must reduce the ripple in the converter output to less than 0.01% even with AC outputs as low as 30 cps, and CR-13 output contains a large AC component. Because of the high series resistance of the output filter, the converter's output voltage will be greatly affected by the load connected to the converter output terminals. The converter's output voltage is correct only when its load is an NLS digital voltmeter with 10 megohms impedance.

7. Auto Range Filter:

This circuit (R-36, R-37, R-38, C-19, C-27, and C-28) filters the output of CR-14 to form a pure negative DC output signal; the time constants are the same as described in the preceding paragraph.

8. Auto Range Reference:

The output of the auto range filter is continuously summed through R-64 and R-68 with reference voltages coming from the reference attenuator (R-5, R-6, R-7, R-8, R-60, and R-61). The attenuator is supplied voltage by the +280-volt regulated power supply.

9. Chopper and Amplifier:

A line synchronous chopper (K-7) driven by Q-2 converts the voltage at the junction of R-64 and R-68 into pulses. The amplitude and polarity of these pulses vary linearly with the difference between the auto range filter voltage and the auto range reference voltage. The pulse amplifier, Q-3 and T-2, amplifies these pulses sufficiently to trigger the UP and DOWN flip-flops.

10. UP and DOWN Flip-Flops:

The flip-flops are triggered by the amplifier and are reset by the chopper driver, Q-2. The state of these flip-flops determines the state of the UP and DOWN pulse lines which control the state of A and B flip-flops.

11. A and B Flip-Flops:

These flip-flops control the 10 V, 100 V, and 1000 V buffers in the automatic mode. Refer to the chart on the main schematic to see the relationships between the UP and DOWN flip-flops, and the A and B flip-flops.

12. Buffers:

The 10 V, 100 V, and 1000 V buffers (Q-4, Q-5, and Q-6) control the range relays (K-3, K-4, K-5, and K-6). They also control the range indicators in the digital voltmeter readout by way of Pins H, K, and J of J-13.

6.4 Tube Socket Voltages

Knowledge of these voltages will be useful for trouble-shooting purposes. Measurements are made with respect to signal ground rather than to chassis ground. Generally, considerable voltage variation can be tolerated. These measurements are made with a line voltage of 115 volts. "FIL" means Filament. In some cases, filaments are operating above ground. Refer to the main foldout schematic at the rear of the manual for filament wiring.

TUBE SOCKET VOLTAGES

Measured with 10 Megohm Input VTVM (HP 410B)

	SOCKET PIN								
TUBE	1	2	3	4	5	6	7	8	9
V-2	150	25	27	Fil	Fil	278	—	150	Fil
V-7	—	1.38	Fil	Fil	278	59	1.38	—	—
V-8	—	1.38	Fil	Fil	137	59	1.38	—	—
V-6	2.6	1	2.6	Fil	Fil	Fil	155	135	2.6
V-3	255	278	Fil	Fil	520	520	255	—	—
V-4	255	278	Fil	Fil	520	520	255	—	—
V-5	258	170	170	Fil	Fil	170	84	85	Fil
V-9	85	—	—	—	85	—	—	—	—

Measured with 20,000 Ohms/Volt Voltmeter

	SOCKET PIN								
TUBE	1	2	3	4	5	6	7	8	9
V-2	150	—	27	Fil	Fil	278	—	150	Fil
V-7	—	1.35	Fil	Fil	275	54	1.35	—	—
V-8	—	1.35	Fil	Fil	135	54	1.35	—	—
V-6	2.5	—	2.5	Fil	Fil	Fil	150	130	2.5
V-3	250	275	Fil	Fil	520	520	250	—	—
V-4	250	275	Fil	Fil	520	520	250	—	—
V-5	258	170	170	Fil	Fil	170	83	84	Fil
V-9	84	—	—	—	84	—	—	—	—

TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
Converter output voltage high (about 24 volts) for any value of input signal.	Feedback voltage is not reaching correction amplifier.	Correct the open circuit or faulty component between conversion diodes and correction amplifier input.
Converter output voltage very low on 100 or 1000 volt ranges.	Range selector switch is on wrong range.	Select proper range.
	Open circuit or faulty resistor in input attenuator.	Replace faulty component.
	Faulty range relay K-3, K-4, K-5, or K-6.	Replace faulty relay.
Converter output exceeds several millivolts with input leads grounded.	Excessive hum pick-up from heater to cathode leakage in some vacuum tube.	Replace faulty vacuum tube.
Converter output zero, or very low and continuously drifting.	Ground fuse, F-2, blown.	Replace fuse. Do not connect "hot" lead to signal "low" side terminal.
	Relays K-1 or K-2 faulty.	Replace faulty relay.
	Faulty vacuum tube.	Replace tubes.
Converter output voltage zero on any one range.	Range calibration pots R-2, R-3, or R-4 open circuited. Range relays K-3 or K-4 faulty.	Replace faulty components.
Converter output much too high on all ranges at all frequencies.	R-138 open circuited.	Replace faulty component.
Converter output continuously drifts.	Low B+ voltage.	Repair power supply or remove excessive load from power supply.
Tube filaments do not light and blower does not operate.	Power fuse, F-1, blown.	Replace fuse. Examine circuits for excessive loads.
When measuring high frequency signals, converter can be almost, but not completely, brought into tolerance.	CR-13 and CR-14 faulty.	Replace.
	Low frequency calibration controls must be readjusted sufficiently to permit bringing calibration in at high frequencies.	Recalibrate entire converter. See calibration procedure.
Converter output very non-linear as a function of input frequency.	Conversion diodes CR-13 or CR-14 are bad.	Replace faulty diodes.
Converter cannot be brought into tolerance on 100 or 1000 volt ranges when measuring low and high frequency signals.	V-1 drawing excessive grid current.	Replace V-1.
Digital voltmeter connected to converter will not measure DC voltages.	K-1 or K-2 faulty.	Replace K-1 or K-2.
Entire AC input signal appears at converter output.	K-1 faulty.	Replace K-1.
Converter will not automatically change range.	Faulty chopper.	Replace K-7.
Readout shows an extra decimal.	Shorted Buffer (Q-4, Q-5, or Q-6).	Replace transistor.

RECOMMENDED SPARE PARTS LIST

This section lists the spare parts which we recommend be stocked for the maintenance of ten (10) Model 125E Converters for a period of one year. If you desire to know the name of the manufacturer, check this list against the parts list given in Section 8. For up-to-date price information, check with your service representative, as listed in the *Appendix*, or contact the NLS home office.

PART NUMBER	DESCRIPTION	REQ. PER UNIT	SPARES REQ.
E1-155E	Capacitor, 1.5μf, 100 V, 10%	7	1
W20228	Capacitor, 0.1μf, 600 V, 20%	1	1
CM-15-E-680-F	Capacitor, 68 $\mu\mu$f, 500 V, $\pm$1%	3	3
CM-15-E-201-F	Capacitor, 200 $\mu\mu$f, 500 V, $\pm$1%	1	1
CM-20E-182-F	Capacitor, 1800 $\mu\mu$f, 500 V, $\pm$1%	1	1
CM-15C-050	Capacitor, 5$\mu\mu$f, 500 V, $\pm$0.5 $\mu\mu$f	1	1
VC5G	Capacitor, .8-18 $\mu\mu$f, 1000 V	2	2
D2-105	Capacitor, 1 μf, 200 V	1	1
PWE50020	Capacitor, 20 μf, 50 V	2	4
D2473E	Capacitor, .047 μf, 200 V	9	1
40B816	Capacitor, 40 μf, 450 V	1	2
30B306	Capacitor, 50 μf, 350 V	2	4
1B1248	Capacitor, 1000 μf, 10 V	1	2
1B1249	Capacitor, 250/250/250 μf, 50 V	1	2
D4-205D	Capacitor, 2 μf, 400 V	1	1
40B817	Capacitor, 10 μf, 450 V	1	2
MW64M4104	Capacitor, .1 μf, 400 V	2	1
XK2-682	Capacitor, .0068 μf, 200 V	1	1
1N429	Diode, Zener, 6 V	1	2
1N2071	Diode, Silicon, 600 V	24	50
1N916	Diode, Silicon, 75 V	2	4
LD-125	Diode, Germanium	19	50
STC-180	Diode, Silicon, 30 V	4	10
1N458	Diode, Silicon, 150 V	4	10
3/4 M14Z5	Diode, Zener, 14 V	1	2

RECOMMENDED SPARE PARTS LIST
(continued)

PART NUMBER	DESCRIPTION	REQ. PER UNIT	SPARES REQ.
313001	Fuse, 3AG, 1 Amp., Slo-Blo	1	10
312002	Fuse, 3AG, 2 Amp.	1	20
55ST-2-32	Lamp (Neon)	2	20
0369	Muffin Fan, Venturi	1	2
0250L-1	Potentiometer, 2KΩ	2	10
0250L-1	Potentiometer, 20KΩ	2	10
0250L-1	Potentiometer, 125KΩ	3	10
BR7Y1KC7	Relay, DPDT	3	10
RP7641-G8	Relay, DPDT, Type F	3	10
HGSS1001	Relay, Mercury	2	10
AW1635	Resistor, 2.2 Meg. ±0.1%, ⅔ W	4	4
PW1719	Resistor, 8 KΩ, ±0.1%, ½ W	1	1
PW1719	Resistor, 76KΩ, ±0.1%, ½ W	1	1
18035-109	Transformer, (Power)	1	2
9000-113	Transformer, (Pulse)	1	2
2N1310	Transistor, NPN	1	2
2N527	Transistor, PNP	4	10
2N651	Transistor, PNP	8	20
2N1305	Transistor, PNP	5	10
6201	Tube, Dual Triode	1	10
6AQ5A	Tube, Pentode	2	20
12AX7	Tube, Dual Triode	1	10
12BY7A	Tube, Pentode	1	10
6136	Tube, Pentode	2	20
5651	Tube, Regulator	1	20

PARTS LIST

This Section lists electrical parts used in the 125E. Hardware items such as brackets, grommets, nuts, and bolts have been deleted. If any unlisted item is required, contact the factory or your regional sales and service representative. Federal supply code numbers, as used in the last column of the listing, are drawn from the *Federal Supply Code for Manufacturers*, Cataloging Handbook H4-1. This publication may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY.	MFR.	FEDERAL SUPPLY CODE
	15004-076	Cable Assembly, AC-DC Converter to Series 20 or 30	1	NLS	03626
	15004-128	Cable Assembly, Output, Series 20	1	NLS	03626
	15004-129	Cable Assembly, Output, Series 30	1	NLS	03626
	18053-020	Basic Converter Assembly	1	NLS	03626
	0369	Muffin Fan, Venturi	1	Rotron	82877
	BR7Y1KC7	Relay, 1.8 to 18.0 V	1	Babcock	82050
	313001	Fuse, 3AG, 1 Amp. Slo-blo	1	Littelfuse	75915
	312002	Fuse, 3AG, 2 Amp.	1	Littelfuse	75915
	18053-109	Transformer, Power	1	NLS-Triad	81095
	18053-015	Range Board Assembly, Output	1	NLS	03626
C-9, C-28	EI-155E	Capacitor (Mylar Ext. Foil) 1.5 mfd, 100 V, 10%	2	Electron	99515
C-10	W20228	Capacitor (Mylar Ext. Foil) 0.1 mfd, 600 V. 20%	1	Westcap	96733
R-60, R-64, R-68, R-138	AW1635	Resistor, 2.2 Meg., ⅔ W, 0.1%	4	NLS	03626
R-63	PW1719	Resistor, 8KΩ, ½ W, 0.1%	1	NLS	03626
R-61	PW1719	Resistor, 76KΩ, ½ W, 0.1%	1	NLS	03626
K-2, K-3, K-4	RP7641-G8	Relay, DPDT, Type F, 675 ohms, 28 VDC, 3/16" Leads	3	C. P. Clare	71482
R-5, R-6	0250L-1	Potentiometer, 2KΩ	2	Con-Elco	06184
R-7, R-8	0250L-1	Potentiometer, 20KΩ	2	Con-Elco	06184
R-2, R-3, R-4	0250L-1	Potentiometer, 125KΩ	3	Con-Elco	06184
	18051-018	Range Board Assembly, Input	1	NLS	03626
C-3, C-4, C-5	CM-15-E-680-F	Capacitor, 68μμf, 500 V, 1% (Silver Mica)	3	Arco	84171
C-6	CM-15-E-201-F	Capacitor, 200 μμf, 500 V, 1% (Silver Mica)	1	Arco	84171
C-7	CM-20E-182-F	Capacitor, 1800 μμf, 500 V, 1% (Silver Mica)	1	Arco	84171

PARTS LIST
(continued)

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY.	MFR.	FEDERAL SUPPLY CODE
R-9, R-10, R-137	MEFT-5	Resistor, 3 Meg., 1 W, 1% (metalized film)	3	IRC	75042
R-45	MEBT-5	Resistor, 900 KΩ, ¼ W, 1% (metalized film)	1	IRC	75042
R-62	MEBT-5	Resistor, 100 KΩ, ¼ W, 1% (metalized film)	1	IRC	75042
K-5, K-6	BR7Y1KC7	Relay, 1.8 to 18.0 V	2	Babcock	82050
R-11	GB1041	Resistor, 100 KΩ, 1 W, 10% (Comp)	1	AB	04061
C-8	CM-15C-050	Capacitor, 5μμf, 500 V, ±.5% (Silver Mica)	1	Arco	84171
C-1, C-2	VC5G	Capacitor, .8 to 18 μμf, 1000 V, (Rotary Trimmed)	2	JFD	73899
V-2	6201	Vacuum Tube, Dual Triode, 9 Pin	1	RCA	49671
V-3, V-4	6AQ5A	Vacuum Tube, Pentode, 7 Pin	2	RCA	49671
V-5	12AX7	Vacuum Tube, Dual Triode, 9 Pin	1	RCA	49671
V-6	12BY7A	Vacuum Tube, Pentode, 9 Pin	1	CBS	97966
V-7, V-8	6136	Vacuum Tube, Pentode, 7 Pin	2	RCA	49671
V-9	5651	Vacuum Tube, Gas Regulator	1	RCA	49671
T-2	9000-113	Transformer, Pulse	1	NLS	03626
V-1, V-10	55ST-2-32	Lamp, Neon, 55 V	2	Signalite	74276
K-7, K-8	HGSS1001	Relay, Mercury	2	C. P. Clare	71482
R-53	GB1041	Resistor, 100 KΩ, 1 Watt, 10%	1	AB	04061
R-12, R-117	GB6831	Resistor, 68 KΩ, 1 Watt, 10%	2	AB	04061
R-13	EB1235	Resistor, 12 KΩ, ½ Watt, 5%	1	AB	04061
R-14	EB1051	Resistor, 10 Meg., ½ Watt, 5%	1	AB	04061
R-17	EB2025	Resistor, 2 KΩ, ½ Watt, 5%	1	AB	04061
R-18, R-19, R-22, R-23, R-37, R-38	MEBT-5	Resistor, 100 KΩ, ¼ Watt, 1%	6	IRC	75042
R-20, R-21	MEBT-5	Resistor, 500 KΩ, ¼ Watt, 1%	2	IRC	75042
R-24, R-36	KC60	Resistor, 120 KΩ, ¼ Watt, 1%	2	KEY	05921
R-25, R-39	KC60	Resistor, 10 KΩ, ¼ Watt, 1%	2	KEY	05921
R-26	Brown Devil	Resistor, 500 Ω, 10 Watt, 5%	1	Ohmite	44655
R-27, R-28	EB2741	Resistor, 270 KΩ, ½ Watt, 10%	2	AB	04061
R-29	EB1001	Resistor, 10 Ω, ½ Watt, 5%	1	AB	04061
R-30, R-31, R-32	Brown Devil	Resistor, 10 Ω, 5 Watts, 5%	3	Ohmite	44655

PARTS LIST
(continued)

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY.	MFR.	FEDERAL SUPPLY CODE
R-33	EB6245	Resistor, 620 KΩ, ½ Watt, 5%	1	AB	04061
R-34	EB2241	Resistor, 220 KΩ, ½ Watt, 10%	1	AB	04061
R-35	EB1221	Resistor, 1.2 KΩ, ½ Watt, 10%	1	AB	04061
R-40	EB1051	Resistor, 1 Meg., ½ Watt, 10%	1	AB	04061
R-41, R-49, R-15, R-112	EB1021	Resistor, 1 KΩ, ½ Watt, 10%	4	AB	04061
R-42	Brown Devil	Resistor, 6 KΩ, 10 Watts, 5%	1	Ohmite	44655
R-43	HB2735	Resistor, 27 KΩ, 2 Watts, 5%	1	AB	04061
R-44, R-46, R-48, R-57	EB1011	Resistor, 100 Ω, ½ Watt, 10%	4	AB	04061
R-47	EB2251	Resistor, 2.2 Meg., ½ Watt, 5%	1	AB	04061
R-50	KC75	Resistor, 56 KΩ, 1 Watt, 1%	1	KEY	05921
R-51, R-54	KC75	Resistor, 43 KΩ, 1 Watt, 1%	2	KEY	05921
R-52	EB4745	Resistor, 470 KΩ, ½ Watt, 5%	1	AB	04061
R-96, R-98, R-127, R-128	GB2721	Resistor, 2.7 KΩ, 1 Watt, 10%	4	AB	04061
R-58, R-70, R-89, R-92	HB1521	Resistor, 1.5 KΩ, 2 Watts, 10%	4	AB	04061
R-94, R-72, R-73, R-91	EB1821	Resistor, 1.8 KΩ, ½ Watt, 10%	4	AB	04061
R-16, R-65	EB2231	Resistor, 22 KΩ, ½ Watt, 10%	2	AB	04061
R-67, R-84, R-130, R-99, R-100, R-107, R-131	EB2721	Resistor, 2.7 KΩ, ½ Watt, 10%	7	AB	04061
R-69	EB2211	Resistor, 470 Ω, ½ Watt, 10%	1	AB	04061
R-71, R-90, R-93	EB8211	Resistor, 820 Ω, ½ Watt, 10%	3	AB	04061
R-75, R-76	EB4731	Resistor, 47 KΩ, ½ Watt, 10%	2	AB	04061
R-77, R-78, R-79, R-82, R-85, R-86, R-105, R-108, R-109, R-74	EB3921	Resistor, 3.9 KΩ, ½ Watt, 10%	10	AB	04061

PARTS LIST
(continued)

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY.	MFR.	FEDERAL SUPPLY CODE
R-80, R-81, R-83, R-88, R-95, R-97, R-103, R-104, R-66, R-106, R-110, R-111, R-113, R-114, R-115, R-116, R-118, R-119, R-120, R-121, R-123, R-124, R-126, R-129, R-133, R-134, R-136, R-125, R-87	EB4721	Resistor, 4.7 KΩ, ½ Watt, 10%	29	AB	04061
R-101, R-102, R-132, R-135	EB1041	Resistor, 100 KΩ, ½ Watt, 10%	4	AB	04061
R-139	Brown Devil	Resistor, 400 Ω, 5 Watts, 5%	1	Ohmite	44655
C-33	D2-105	Capacitor, 1 mfd, 200 V	1	Electron	99515
C-13, C-15, C-16, C-19, C-27	E1-155E	Capacitor, 1.5 mfd, 100 V, 10% (Mylar Ext. Foil)	5	Electron	99515
C-11, C-14	PWE50020	Capacitor, 20 mfd, 50 V (Ceramic Cased)	2	Aerovox	97262
C-12, C-34, C-35, C-36, C-37, C-38, C-39, C-22, C-23	D2-473E	Capacitor, .047 mfd, 200 V, 10% (Mylar Ext. Foil)	9	Electron	99515
C-31	40B816	Capacitor, 40 mfd, 450 V Royalitic, P.C.)	1	Ind.Cond.Corp.	74861
C-17, C-18	30B306	Capacitor, 50 mfd, 350 V (Royalitic, P.C.)	2	Ind.Cond.Corp.	74861
C-20	1B1248	Capacitor, 1000 mfd, 10 V (Royalitic, P.C.)	1	Ind.Cond.Corp.	74861
C-21	1B1249	Capacitor, 250/250/250 mfd, 50 V (Royalitic, P.C.)	1	Ind.Cond.Corp.	74861
C-24	D4-205D	Capacitor, 2 mfd, 400 V	1	Electron	99515
C-25	40B817	Capacitor, 10 mfd, 450 V (Royalitic, P.C.)	1	Ind.Cond.Corp.	74861
C-26	E4-224E	Capacitor, .22 mfd, 400 V, 10%	1	Electron	99515
C-29, C-30	MW64M4104	Capacitor, .1 mfd, 400 V	2	Westcap	96733
C-32	XK2-682	Capacitor, .0068 mfd, 200 V	1	Electron	99515
CR-1	1N429	Diode, Zener, Silicon 6 V	1	Hoffman	28959

PARTS LIST
(continued)

REFERENCE CIRCUIT	PART NUMBER	DESCRIPTION	QTY.	MFR.	FEDERAL SUPPLY CODE
CR-2, CR-3, CR-4, CR-5, CR-6, CR-7, CR-8, CR-9, CR-10, CR-11, CR-12, CR-23, CR-24, CR-25, CR-32, CR-33, CR-34, CR-38, CR-39, CR-40, CR-46, CR-47, CR-15, CR-16	1N2071	Diode, Silicon, 600 PIV.	24	Texas Instruments	01295
CR-13, CR-14	1N916	Diode, Silicon, 75 V	2	Texas Instruments	01295
CR-21, CR-22, CR-26, CR-27, CR-28, CR-29, CR-30, CR-31, CR-35, CR-36, CR-37, CR-41, CR-43, CR-44, CR-45, CR-48, CR-49, CR-53, CR-54	LD-125	Diode, Gemanium	19	CBS	97966
CR-42, CR-52, CR-50, CR-51	STC-180	Diode, Silicon, 30 V	4	Silicon Tr. Corp.	07256
CR-17, CR-18, CR-19, CR-20	1N458 (HD6007)	Diode, Silicon, 150 V, PIV.	4	Hughes	73293
CR-55	¾ M14Z5	Diode, Zener, Silicon, 14 V	1	Motorola	04713
Q-1	2N1310	Transistor, Germanium, NPN	1	GT	04662
Q-2, Q-4, Q-5, Q-6	2N527	Transistor, Germanium, PNP	4	GE	03508
Q-7, Q-8, Q-9, Q-10, Q-11, Q-12, Q-13, Q-19	2N651	Transistor, Germanium, PNP	8	Motorola	04713
Q-15, Q-16, Q-17, Q-18, Q-3	2N1305	Transistor, Germanium, PNP	5	Texas Instruments	01295

Model 125B

The Model 125B uses the parts listed on the preceding pages for the 125E except:

Delete

Resistors:
R-29, R-57, R-58, R-60, and R-64 through R-139.

Capacitors:
C-14, C-20, C-22, C-23, C-28, and C-32 through C-39.

Transformer:
T-2.

Relays:
K-2, K-7, and K-8.

Diodes:
CR-15, CR-16, CR-22 through CR-41, CR-43 through CR-49, CR-53, and CR-55.

Transistors:
Q-2 through Q-19.

Add

S-1, Switch, selector, 18069-009 NLS 03626

Model 125C

The Model 125C uses the same parts as the 125B except:

Delete

S-1, Switch, selector, 18069-009 NLS 03626

Add

K-2, relay.

NON-LINEAR SYSTEMS, INC.
Del Mar, California

TECHNICAL INFORMATION BULLETIN

CALIBRATING AC DIGITAL VOLTMETERS

INTRODUCTION

The method that is generally accepted for calibrating the most precise AC voltmeters is a technique developed by F. L. Hermach at the National Bureau of Standards (see Reference). It is called the transfer thermocouple method, because the reading of accurate DC voltage measuring devices standardized against cadmium-mercury standard cells, is transferred to AC measurements. In this method of measuring AC voltage, the unknown AC is supplied to the heater of an instrument thermocouple, and the generated thermoelectric potential is measured by a millivoltmeter. The thermocouple heater is then connected to a DC power supply, and the voltage varied until the millivoltmeter reads the same thermoelectric potential as it did when the unknown AC was applied to the heater element. Absolute accuracy of the millivoltmeter is not important, but very fine resolution and repeatability are. The DC power supply voltage is then accurately measured and its value is, by definition, the true rms value of the AC voltage.

NLS PROCEDURE

All NLS AC-DC converters are calibrated against a Hermach-Engelhard Transfer Volt Ammeter. The NLS Hermach-Engelhard instrument has been certified by the National Bureau of Standards to plus or minus 0.05%. A variable turns ratio transformer accurate to plus or minus .001% is used to cover different ranges. Step by step instructions for calibration for specific models manufactured by NLS are included in each instrument's handbook.

EQUIPMENT USED

The calibration setup used at NLS is shown in Figure 1. The Hermach-Engelhard Transfer Volt Ammeter, which has ranges from 15 to 300 volts, is certified by NBS from 20 to 20,000 cps. The AC voltage source used for calibration must be stable enough to permit transferring the DC reading to AC without significant voltage output change. Also, harmonic distortion must be low, for the AC digital voltmeter reads in proportion to the waveform average value, but is normally calibrated in terms of the rms value of a pure sine wave. The power supply must cover the voltage and frequency range required with enough power to drive the thermocouple. NLS uses a special oscillator with a 0.05% maximum harmonic distortion, 0.01% short term drift, 6 watts maximum power output. 0.05% harmonic distortion produces much less than 0.1% error. An accurate attenuator is connected at AA in Figure 1 to extend the range. The Gertsch variable turns ratio transformer is used for this purpose and for checking that the AC digital voltmeter's 10, 100 and 1,000 volt scale multipliers are adjusted correctly.

SUBSTITUTED EQUIPMENT

If the customer desires to calibrate AC digital voltmeters but does not have Hermach-Englehard equipment, a Weston type V-I (insulated bead) instrument thermocouple and a millivoltmeter with high resolution and repeatability can be used. In the absence of thermocouple equipment, a precision laboratory AC voltmeter of the dynamometer type can be used for less accurate tests and over a restricted frequency range.

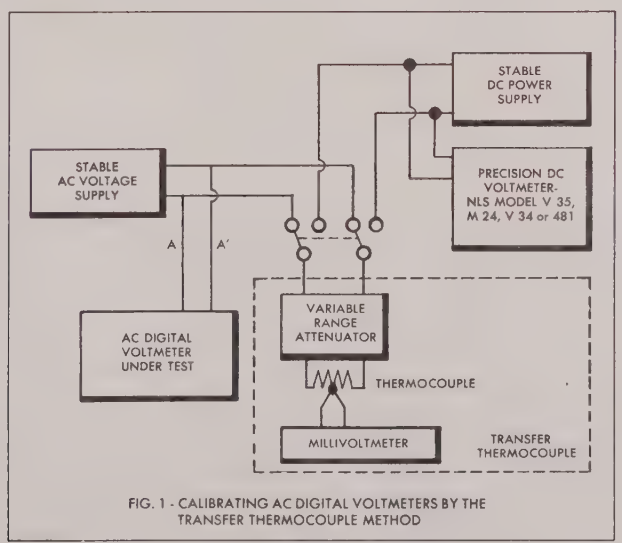


FIG. 1 - CALIBRATING AC DIGITAL VOLTMETERS BY THE TRANSFER THERMOCOUPLE METHOD

FIGURE 1

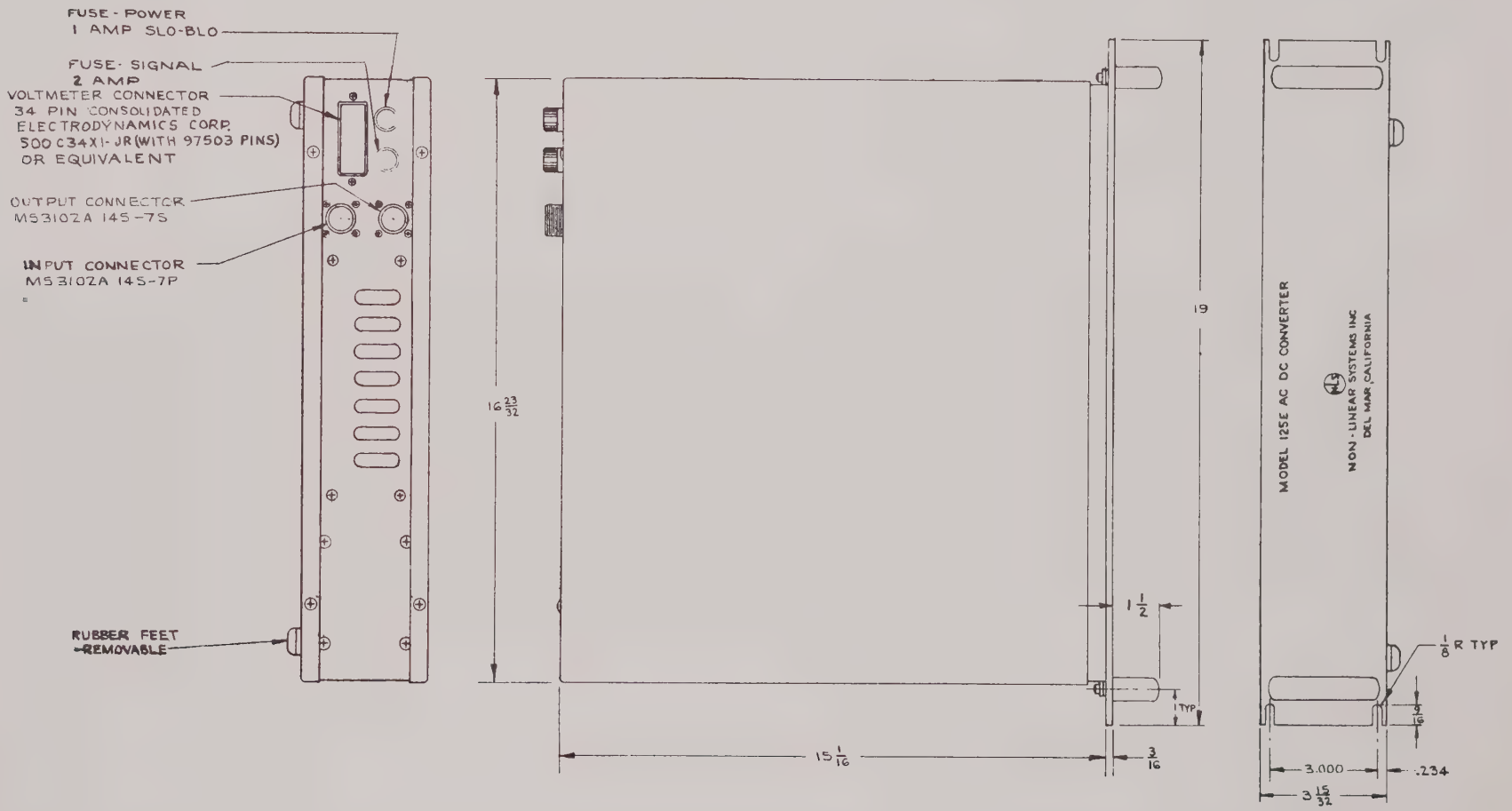
Calibrating AC Digital Voltmeters By The Transfer Thermocouple Method

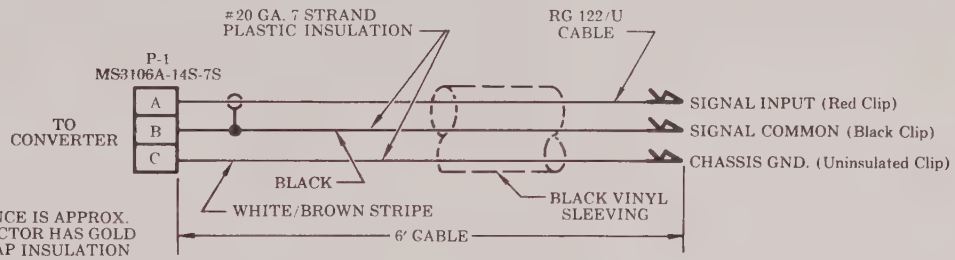
NOTE:

For calibration, NLS now uses the Holt Model TV1 Thermal Transfer Standard certified by the U.S. National Bureau of Standards to ±0.01% over most of its operating range of 20 cps to 20 kc.

The AC source is the low distortion Holt Audio Voltage Standard.

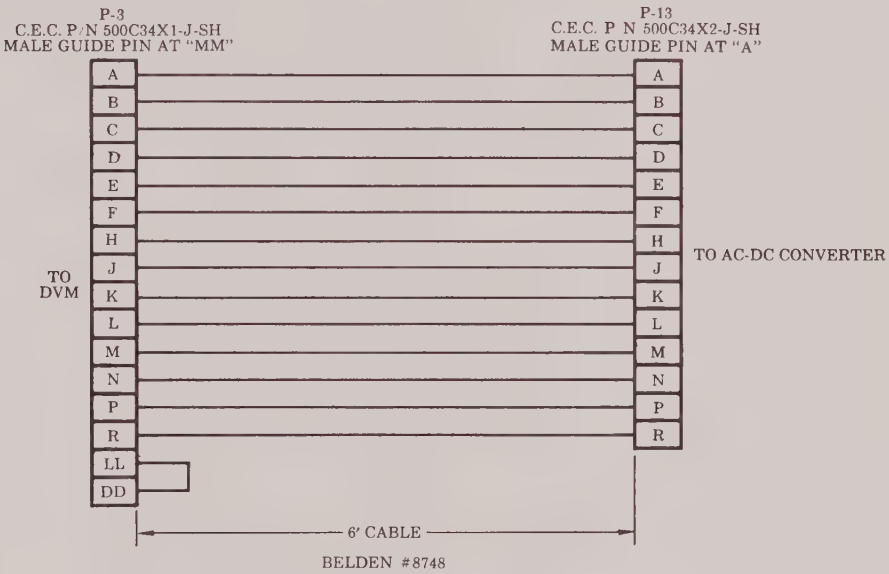
References: Hermach & Williams - Multirange, A.F. Thermocouple Insts. Research Paper 2494 - U.S. Gov't Printing Office (bound in Vol. 52, Journal of Research, N.B.S.) - Hermach - Thermal Converters as Transfer Standards, Research Paper 2296 - U.S. Gov't Printing Office (bound in Vol. 48, Journal of Research, N.B.S.)


FUSE - POWER
1 AMP SLO-BLO
FUSE - SIGNAL
2 AMP
VOLTMETER CONNECTOR
34 PIN CONSOLIDATED
ELECTRODYNAMICS CORP.
500 C34X1-JR (WITH 97503 PINS)
OR EQUIVALENT
OUTPUT CONNECTOR
MS3102A 14S-7S
INPUT CONNECTOR
MS3102A 14S-7P
RUBBER FEET
-REMOVABLE
16 23/32
19
1 1/2
.1 TYP
15 1/16
3/16
MODEL 125E AC DC CONVERTER
NON-LINEAR SYSTEMS INC
DEL MAR, CALIFORNIA
1/8 R TYP
3.000
.234
3 15/32

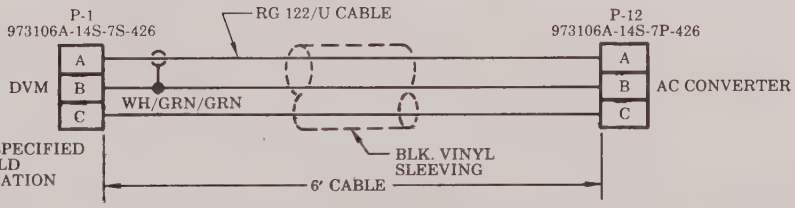


NOTE:
CABLE CAPACITANCE IS APPROX.
28 uuf/foot. CONNECTOR HAS GOLD
CONTACTS AND DAP INSULATION

CABLE ASSEMBLY #15004-075

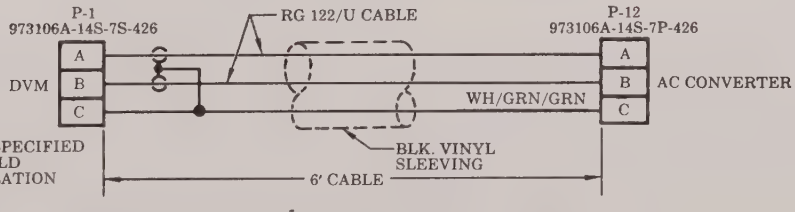


BELDEN #8748



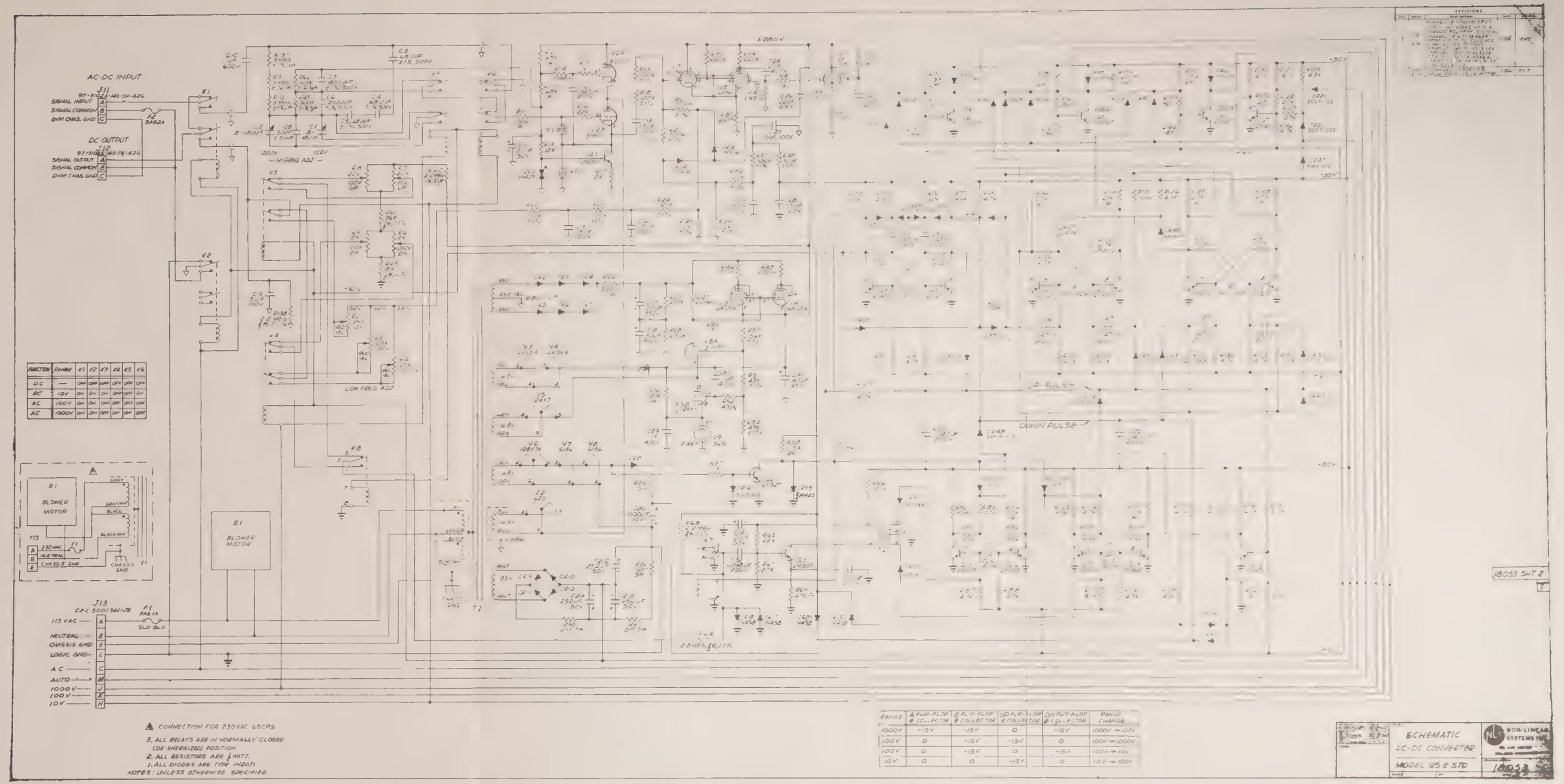
NOTE: UNLESS OTHERWISE SPECIFIED
1. CONNECTORS TO HAVE GOLD
CONTACTS AND DAP INSULATION
2. MARK DWG NO. 15004-128
ON VINYL SLEEVING

CABLE ASSEMBLY OUTPUT, AC CONVERTER
MODEL 125E TO SERIES 20 OR 40



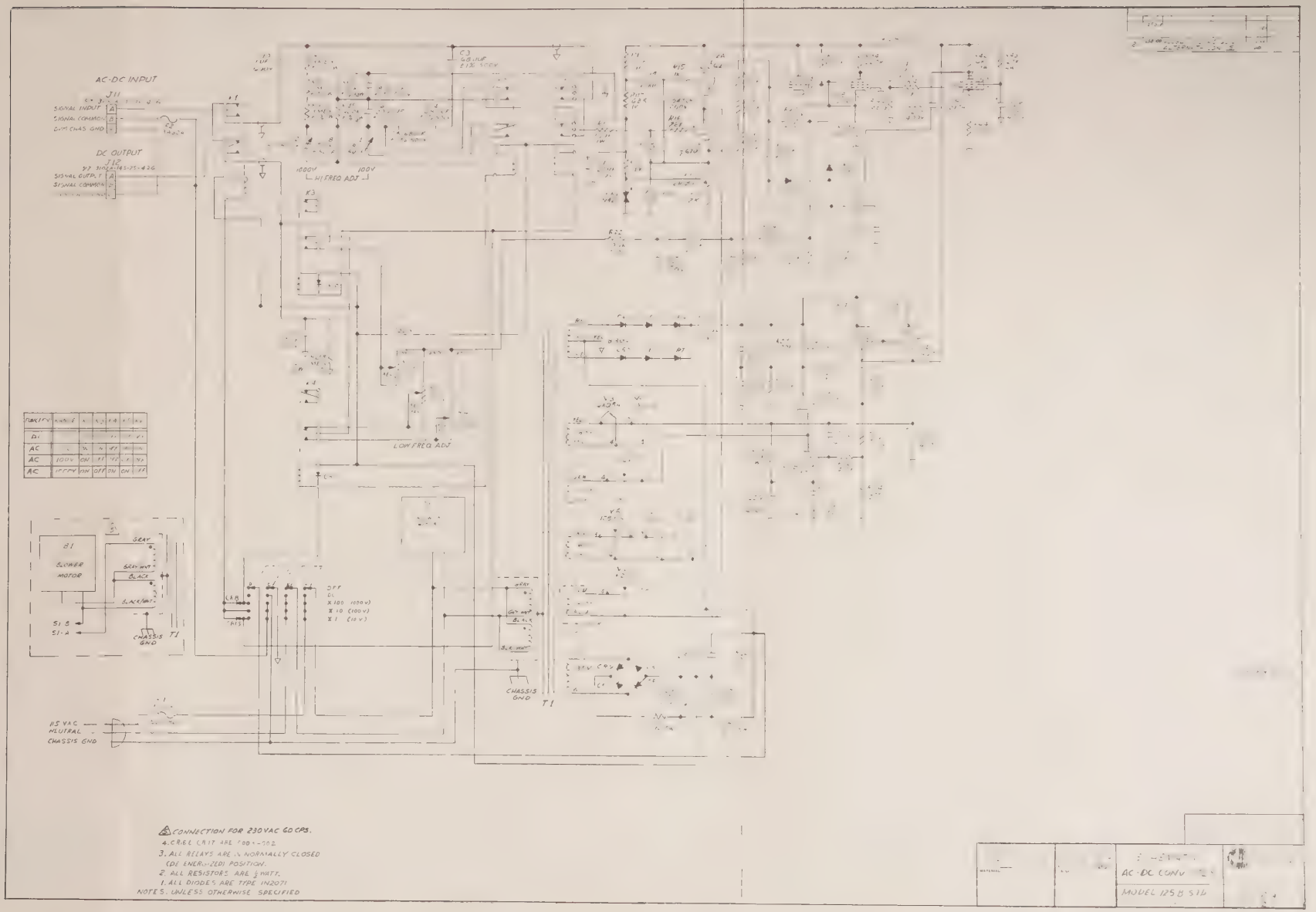
NOTE: UNLESS OTHERWISE SPECIFIED
1. CONNECTORS TO HAVE GOLD
CONTACTS AND DAP INSULATION
2. MARK DWG NO. 15004-129
ON VINYL SLEEVING

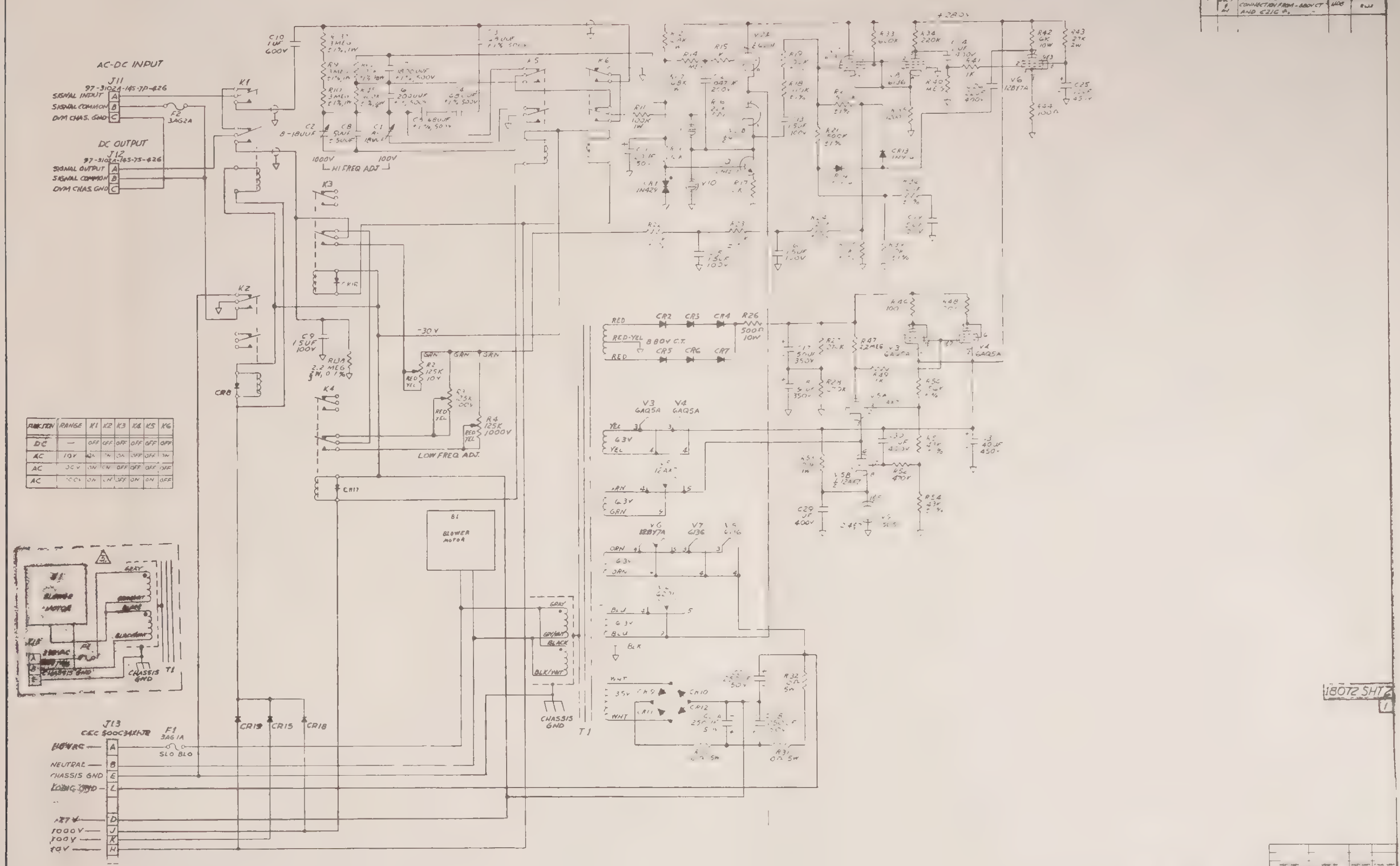
CABLE ASSEMBLY OUTPUT AC CONVERTER
MODEL 125E TO SERIES 30



FUNCTION	RANGE	K1	K2	K3	K6	K5	K4
DC	—	OFF	OFF	OFF	OFF	OFF	OFF
AC	10V	ON	ON	ON	OFF	OFF	ON
AC	100V	ON	ON	OFF	OFF	OFF	OFF
AC	1000V	ON	ON	OFF	ON	ON	OFF

RANGE	A FLIP-FLOP @ COLLECTOR	B FLIP-FLOP @ COLLECTOR	UP FLIP-FLOP @ COLLECTOR	DN FLIP-FLOP @ COLLECTOR	RANGE CHANGE
1000V	-15V	-15V	0	-15V	1000V → 100V
100V	0	-15V	-15V	0	100V → 1000V
100V	0	-15V	0	-15V	100V → 10V
10V	0	0	-15V	0	10V → 100V


AC-DC INPUT
J11
SIGNAL INPUT
SIGNAL COMMON
CHAS GND
DC OUTPUT
J12
SIGNAL OUTP. T.
SIGNAL COMMON
1000V
100V
HI FREQ ADJ
LOW FREQ ADJ
B1
BLOWER MOTOR
GRAY
GRAY WHT
BLACK
BLK/WHT
S1-B
S1-A
CHASSIS GND
T1
OFF
X100 (1000V)
X10 (100V)
X1 (10V)
115 VAC
NEUTRAL
CHASSIS GND
CONNECTION FOR 230 VAC 60 CPS.
4. CABLE CA11 ARE 7003-7002.
3. ALL RELAYS ARE IN NORMALLY CLOSED (DE ENERGIZED) POSITION.
2. ALL RESISTORS ARE ½ WATT.
1. ALL DIODES ARE TYPE IN2071
NOTES: UNLESS OTHERWISE SPECIFIED
AC-DC CONV
MODEL 125 B S/N



AC-DC INPUT
J11
97-3102A-14S-7P-426
SIGNAL INPUT
SIGNAL COMMON
DVM CHAS. GND
F2
3AG2A
DC OUTPUT
J12
97-3102A-14S-7S-426
SIGNAL OUTPUT
SIGNAL COMMON
DVM CHAS. GND
K1
K2
K3
K4
K5
K6
C10
1UF
600V
C2
8-18UUF
C8
C1
1000V
100V
HI FREQ ADJ
R11
100K
1W
1N429
R17
R18
R21
R34
220K
R33
R41
1K
R40
V6
12BY7A
R42
6K
10W
R43
27K
2W
C25
R44
100Ω
CR13
CR16
C9
15UF
100V
R13A
2.2 MEG
½W, 0.1%
-30V
GRN
R2
125K
10V
RED
YEL
R4
125K
1000V
LOW FREQ ADJ.
CR8
CR17
RED
RED-YEL
880V C.T.
CR2
CR3
CR4
CR5
CR6
CR7
R26
500Ω
10W
R27
R24
R47
2.2MEG
V3
6AQ5A
V4
6AQ5A
R46
100
R48
R49
1K
R50
R55
470K
R54
C29
400V
V5B
½ 12AX7
40UF
450V
6.3V
YEL
GRN
ORN
BLU
BLK
WHT
35V
V6
12BY7A
V7
6136
B1
BLOWER MOTOR
GRAY
GRY/WHT
BLACK
BLK/WHT
CHASSIS GND
T1
CR9
CR10
CR11
CR12
50V
R32
5W
R31
0Ω 5W
CR14
CR15
CR18
J13
CEC 500C34XHJR
F1
3AG 1A
SLO BLO
NEUTRAL
CHASSIS GND
LOGIC GND
1000V
100V
10V
+280V
18072 SHT 2

FUNCTION	RANGE	K1	K2	K3	K4	K5	K6
DC	—	OFF	OFF	OFF	OFF	OFF	OFF
AC	10V	ON	ON	ON	OFF	OFF	ON
AC	100V	ON	ON	OFF	OFF	OFF	OFF
AC	1000V	ON	ON	OFF	ON	ON	OFF

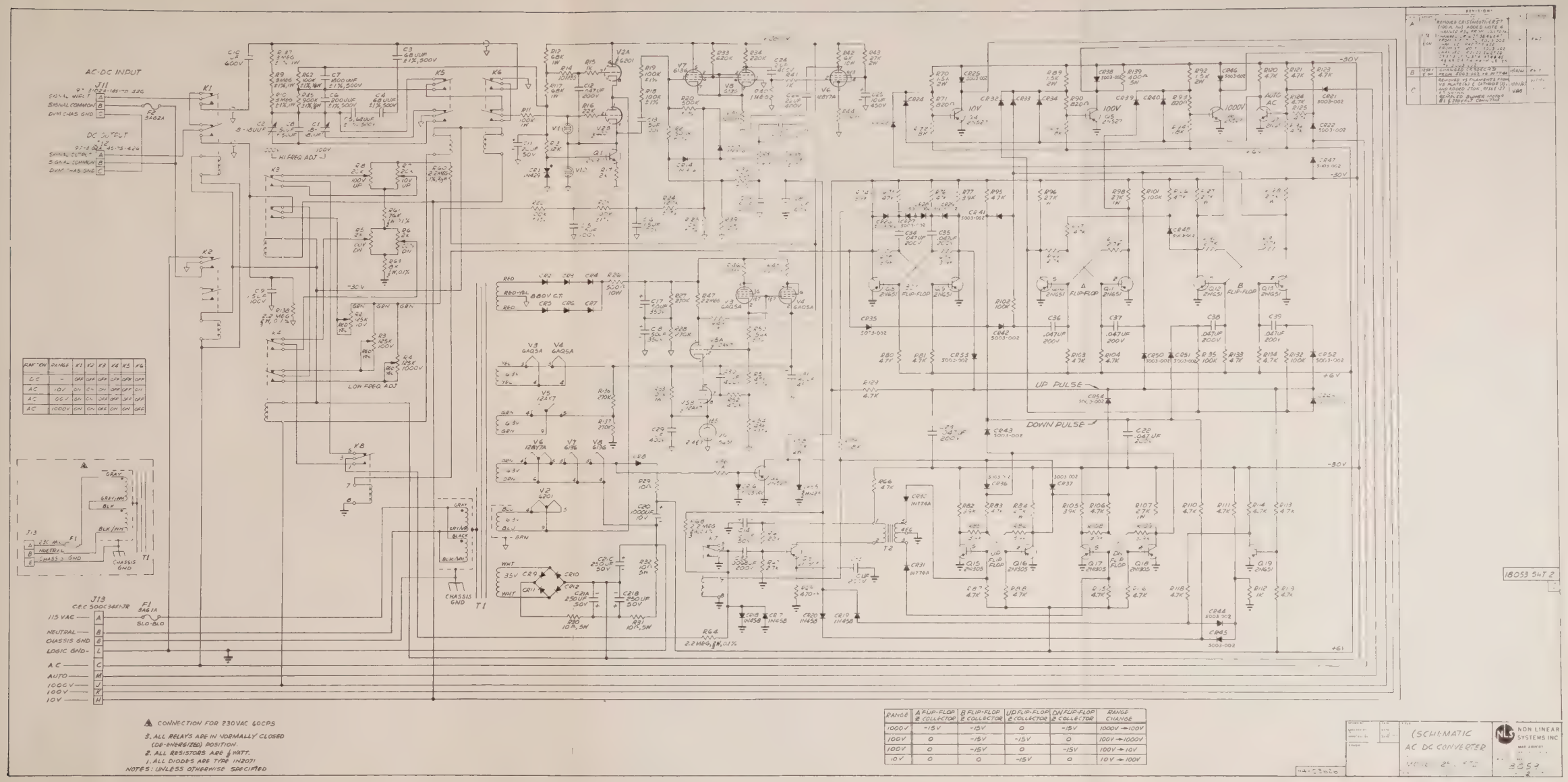
⚠5 CONNECTION FOR 230VAC 60CPS.
4. REMOVE WIRE TO J13-D WHEN MATING TO THE M24 S/N 10,700 AND ON
3. ALL RELAYS ARE IN NORMALLY CLOSED (DE-ENERGIZED) POSITION.
2. ALL RESISTORS ARE ½ WATT.
1. ALL DIODES ARE TYPE IN2071
NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS: 1 — ADD NOTE ⚠ REMOVED CONNECTION FROM -880V CT AND C21C +.

SCHEMATIC
AC-DC CONVERTER
MODEL 125? STD

NON-LINEAR SYSTEMS INC
DEL MAR AIRPORT
DEL MAR CALIFORNIA

18072
SHEET 2



RANGE	A FLIP-FLOP @ COLLECTOR	B FLIP-FLOP @ COLLECTOR	UD FLIP-FLOP @ COLLECTOR	DN FLIP-FLOP @ COLLECTOR	RANGE CHANGE
1000 V	-15V	-15V	0	-15V	1000V → 100V
100V	0	-15V	-15V	0	100V → 1000V
100V	0	-15V	0	-15V	100V → 10V
10V	0	0	-15V	0	10V → 100V

RANGE	RANGE	K1	K2	K3	K4	K5	K6
DC	-	OFF	OFF	OFF	OFF	OFF	OFF
AC	10V	ON	ON	ON	OFF	OFF	ON
AC	100V	ON	ON	ON	OFF	ON	OFF
AC	1000V	ON	ON	OFF	ON	ON	OFF

▲ CONNECTION FOR 230VAC 60CPS

3. ALL RELAYS ARE IN NORMALLY CLOSED (DE-ENERGIZED) POSITION.
2. ALL RESISTORS ARE ½ WATT.
1. ALL DIODES ARE TYPE IN2071

NOTES: UNLESS OTHERWISE SPECIFIED

NON-LINEAR SYSTEMS, INC.

DEL MAR, CALIFORNIA
714-755-1134 TWX 714-277-3191

LIST OF NLS REPRESENTATIVES

Alabama, Huntsville
ROY ATTAWAY CO.
900 Bob Wallace Avenue
205-534-2811
TWX 205-533-1714

Arizona, Scottsdale
AR/TEC, INC.
14 Stetson Drive
P. O. Box 727
602-947-6304
TWX 602-949-0183

California, Palo Alto
BERT OPPENHEIM, INC.
2179 Park Blvd.
415-321-7323

California, South Pasadena
Q. P. L., INC.
1015 Fremont Avenue
P. O. Box 338
213-682-3705

Colorado, Denver
PETERSON COMPANY
4949 Colorado Blvd.
303-333-5434

Florida, Orlando
JIM WHITTINGTON
705 W. Colonial Drive
305-423-8901

Illinois, Chicago
MEGATEK, INC.
1915 N. Harlem Avenue
312-889-1277

Kansas, Mission
PALATINE ENG. SALES, INC.
5514 Johnson Drive
913-262-5643

Maryland, Crofton
ELECTRONIC SALES ASSOC.
9 Village Green
301-932-8660

Massachusetts, Waltham
MICHAEL GUALIANO
Suite 11, 195 West Street
617-899-1430

Michigan, Detroit
MEGATEK, INC.
26847 Grand River Ave.
313-531-1403

Minnesota, Minneapolis
TORKELSON ASSOC. INC.
4820 W. 77th Street
612-920-1046
TWX 612-321-0803

Missouri, St. Louis
PALATINE ENG. SALES, INC.
8587 St. Charles Rock Rd.
314-426-7055

New Jersey, Caldwell
WILLIAM KIEVIT
387 Passaic Avenue
201-228-2525

New Jersey, Cherry Hill
MICHAEL GUALIANO
1500 King's Highway
609-428-1663

New Mexico, Albuquerque
AR/TEC, INC.
2800 Cardenas Dr., NE
505-268-3324

New York, Buffalo
Robert F. LAMB CO., INC.
3407 Delaware Avenue
716-876-3757
TWX 716-858-1330

New York, Fishkill
RICHARD HAHN
114 Main Street
914 896-6294

New York, Jericho, L. I.
FRANK BATTISTA
50 Jericho Turn Pike
516-333-7020

New York, Kingston
ROBERT F. LAMB CO., INC.
P. O. Box 661, Uptown Sta.
914-338-8833

New York, Syracuse
ROBERT F. LAMB CO., INC.
P. O. Box 28
315-454-2469

North Carolina, Winston Salem
ROY ATTAWAY CO.
519 Nissen Bldg.
919-722-9671

Ohio, Dayton
MEGATEK, INC.
2533 Far Hills Avenue
513-298-8638

Oklahoma, Tulsa
APPLIED SCIENCE ASSOC.
7966 E. 41st Street
918-627-6199

Texas, Dallas
APPLIED SCIENCE ASSOC.
3707 Rawlins
214-526-8316
TWX 214-899-9050

Texas, Houston
APPLIED SCIENCE ASSOC.
5716 Southwest Freeway
713-781-1441

Texas, San Antonio
JOHN W. CASEY
7078 San Pedro, Suite 206
512-824-6368
TWX 512-571-0788

Utah, Salt Lake City
PETERSON COMPANY
521 W. 4th N.
P. O. Box 16046
801-355-7464

Washington, Bellevue
BILL BRENNAN
208 Carlson Bldg.
206-454-9332

Puerto Rico, San Juan
FLAN ASSOCIATES
P. O. Box 6283
809-725-0759

Canada
ELECTRONETIC SYS. LTD.
62 Alness Street
Downsview, Ontario
416-636-3673

Canada
ELECTRONETIC SYS. LTD.
6240 Victoria Ave., Suite 17
Montreal, Quebec
514-737-2744

OVERSEAS: NLS is represented in many countries. Please consult factory in Del Mar, California

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12-11

REVISIONS

SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED

DWG NO	SIZE	TITLE
12-12	C	AC-DC CONVERTER
1363	D	TIME DELAY
15004-500	B	CABLE
15004-129	C	CABLE

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS = .010 ANGLES = 0° 30'
FRACTIONS = 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 4-19-66

DRAWN R J 4-13-66
CHECK
APPR 4-18-66
MATERIAL
FINISH

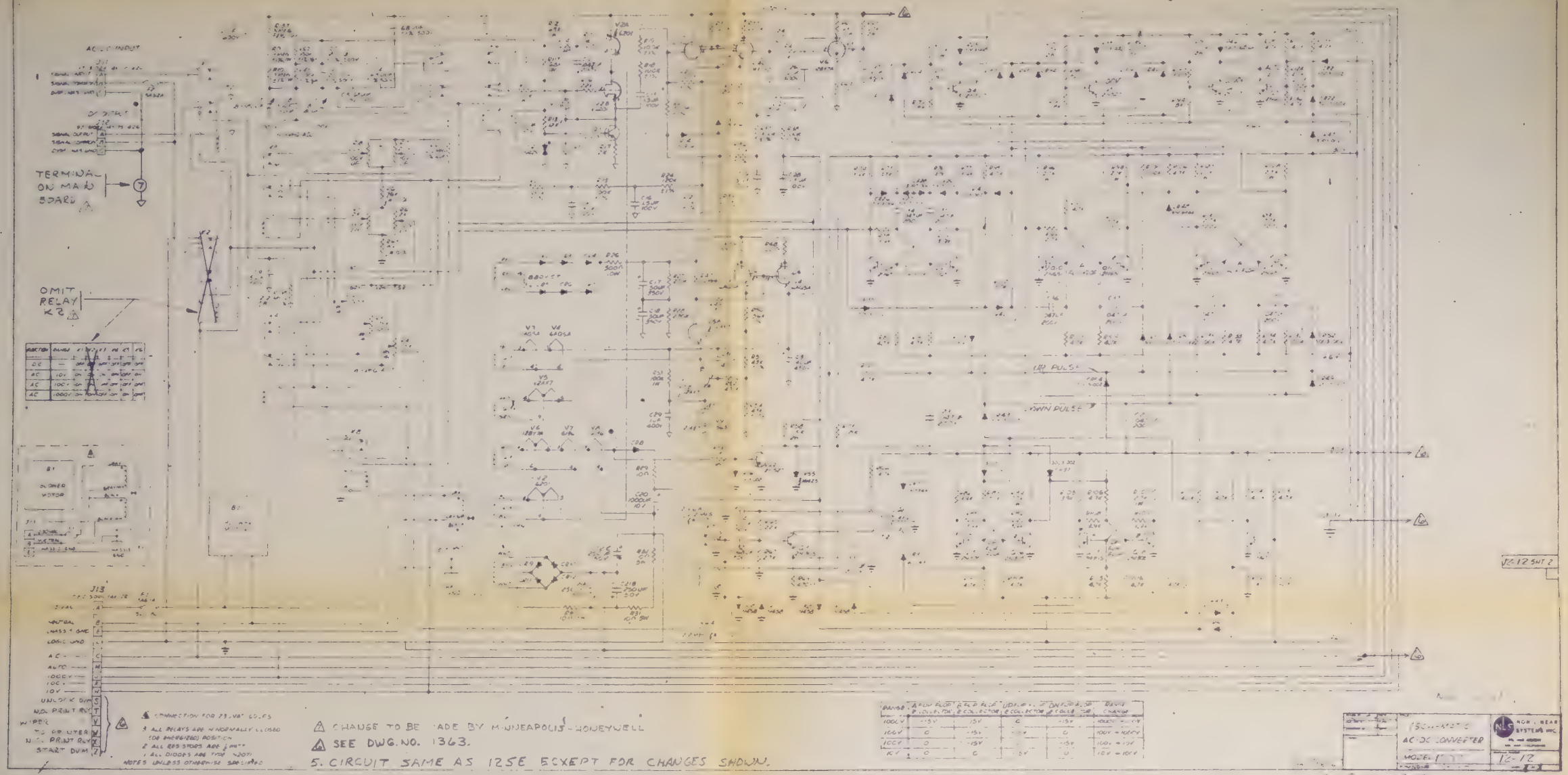
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC LIST, AC-DC CONVERTER
MODEL 1207

CODE IDENT NO.	SIZE	
03626	A	12-11
SCALE	WEIGHT	SHEET 1

1. REF. MINNEAPOLIS HONEYWELL DWG. NO. D1989206-1.

NOTES:



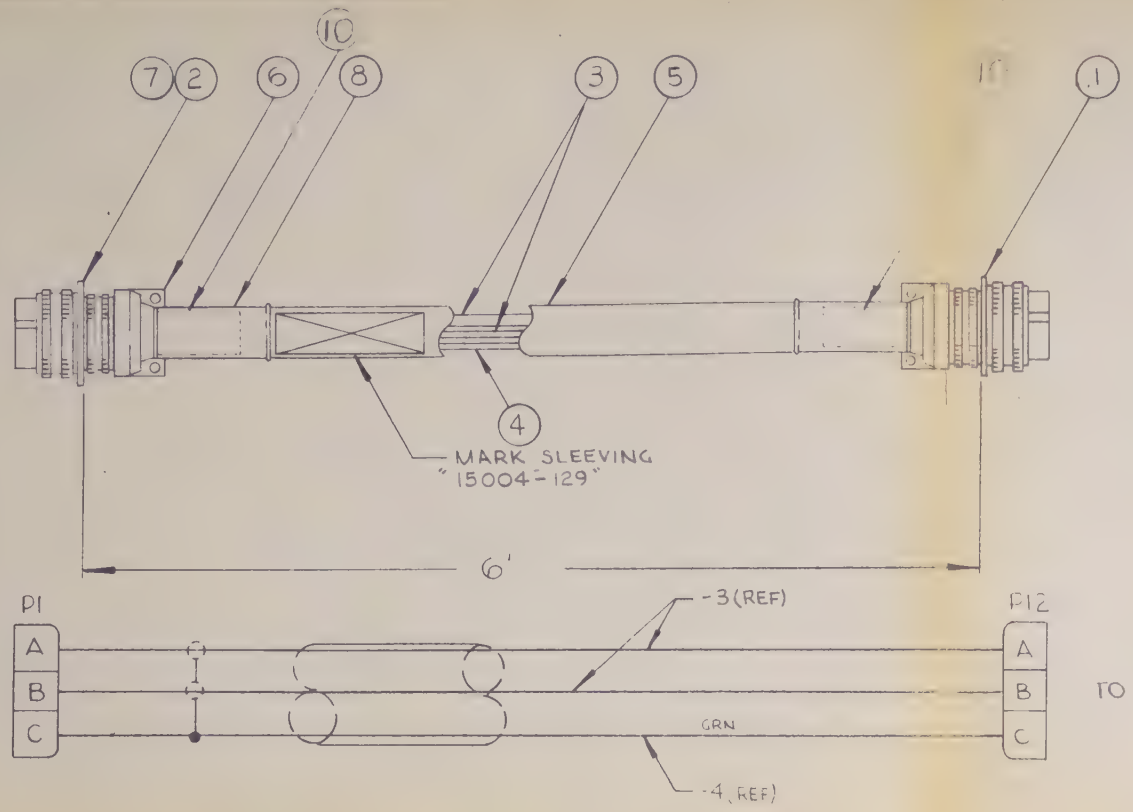
4. CONNECTION FOR 23 VAT COILS
3. ALL RELAYS ARE IN NORMALLY CLOSED (DE ENERGIZED) POSITION
2. ALL RESISTORS ARE ¼ WATT
1. ALL DIODES ARE TYPE 4207
NOTES UNLESS OTHERWISE SPECIFIED

⚠ CHANGE TO BE MADE BY MINNEAPOLIS-HONEYWELL
⚠ SEE DWG. NO. 1363.
5. CIRCUIT SAME AS 125E EXCEPT FOR CHANGES SHOWN.

RANGE	A FLOW FLOP B COLLECTOR	B FLIP FLOP B COLLECTOR	UDAMP C COLLECTOR	DAC FLOP D COLLECTOR	DAC OUT CHANGE
100 V	-15V	15V	0	-15V	100V → -10V
10 V	0	-15V	15V	0	10V → 100V
1 V	0	-15V	0	-15V	1V → 10V
.1 V	0	0	5V	0	.1V → 1V

SCHEMATIC
AC-DC CONVERTER
MODEL 12
12-12
NLS NORTHEAST LABORATORY SYSTEMS INC.

REVISIONS				
SYM	EFFECT	DESCRIPTION	DATE	APPROVAL
A	ALL	REVISED & REDRAWN - LAST CHG "O"	5-21-62	
B	ALL	CORRECTED ITEM 6 - WAS MS 3057-6B	1-29-63	
C	ALL	ITEMS 3, 4 & 5 QTY WAS A/R, ITEMS 5 WALL WAS .02 & ADDED BLACK	11-64	



LIST OF MANUFACTURERS	
NAME	ADDRESS
AMPERITE CO.	NEW YORK, N.Y.
AMPHENOL CORP.	BROADVIEW, ILL.
BELDEN CO.	CHICAGO, ILL.
ALPHA WIRE CORP.	NEW YORK, N.Y.
ILLUMITRONIC ENG. CO.	SUNNYVALE, CALIF.

NOTES:
1. ALL SOLDER CONNECTION TO BE PER MIL-S-6872.

H4-03626

15004-129
C

ITEM	REQ'D	PART NUMBER	DESCRIPTION	MATERIAL OR MANUFACTURER	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
			LIST OF MATERIAL		APPLICATION		QTY REQD	
10	6"	#12	SHRINK TUBING, BLACK					
9	A/R	22-[illegible]	SOLDER,					
8	2	32-[illegible]	FERRULE, TERMASHIELD	AMP				
7	2	8022-6	INSERT, RUBBER	AMPHENOL				
6	2	MS3057-6A	CLAMP,					
5	[illegible]	VT53	SLEEVING, VINYL 5/16" ID .025 V[illegible]	[illegible] ILL				
4	[illegible]	1553	WIRE, TYPE MW 20GA. PLASTIC INSULATED, GRN	ALPHA				
3	[illegible]	RG122/U	CABLE, COAXIAL	BELDEN				
P1 2	1	97-3106A-14S-2P	CONNECTOR, BLUE D.A.P. GOLD	AMPHENOL				
P2 1	1	97-3106A-14S-2P	CONNECTOR, BLUE D.A.P. GOLD	AMPHENOL	18077	18077	1	1

UNLESS OTHERWISE SPECIFIED	DRAWN BY	DATE	TITLE	NON-LINEAR SYSTEMS INC.
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTION ± 1/32 DECIMAL ± ~ ANGLES ± ~	CUBAN D&M	5-21-62	CABLE, OUTPUT, ASSY. AC CONVERTER MODEL 125 E TO SERIES 30	DEL MAR AIRPORT DEL MAR, CALIFORNIA
MATERIAL	CHECKED BY [illegible]	DATE 6-22-62	MODEL 125E STD	DRAWING NUMBER 15004-129
FINISH	APPROVED BY [illegible]	DATE 5-26-62	SCALE 1 TO 1 WT. ~	SHEET 1 OF 1

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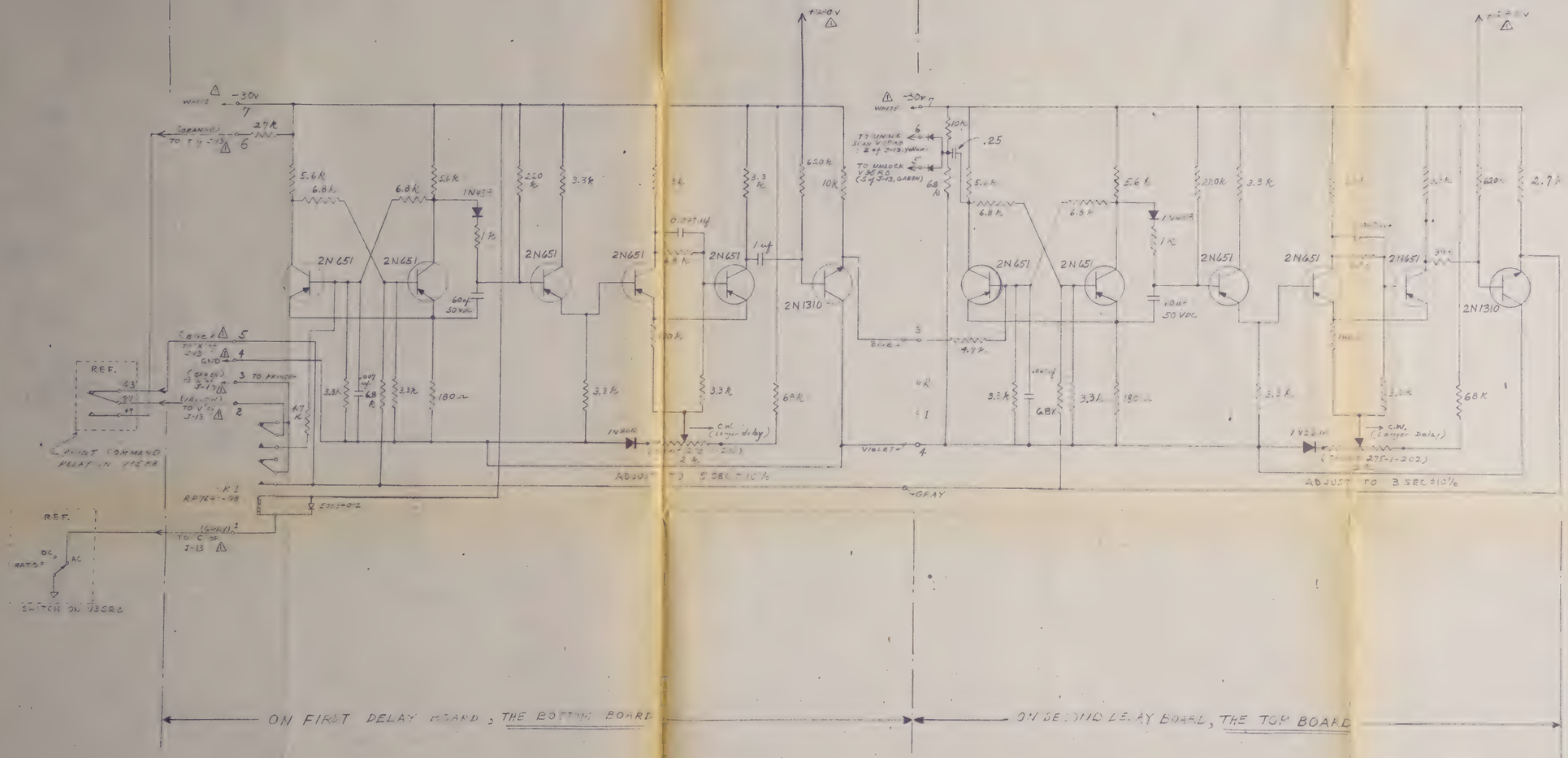
REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED

SCHEMATIC DIAGRAM OF THE DELAY USED FOR SPECIAL S.O. 309A034



ON FIRST DELAY BOARD, THE BOTTOM BOARD

ON SECOND DELAY BOARD, THE TOP BOARD

NOTES: ⚠ SEE D.W.G. NO. 12-

2. MAKE FROM P/C NO. 18067-010.

FIRST USED ON MINNEAPOLIS HONEYWELL S.O. 309A034

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
PARTS LIST						12-11			1
						APPLICATION			QTY.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 | ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 4-18-64

DRAWN Benito DY
CHECK
APPR
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

TIME DELAY SCHEMATIC
AC-DC CONVERTER
MODEL 1207

CODE IDENT NO.	SIZE	
03626	D	1363
SCALE	WEIGHT	SHEET

15004-500

REVISIONS					
ZONE	LTR	EFFECT.	DESCRIPTION	DATE	APPROVED

P3
AMP 201984-1/42974-1(20)
MALE GUIDE PIN AT "MM"

P13
AMP 201987-1/42975-1(20)
MALE GUIDE PIN AT "A"

UNLESS OTHERWISE SPECIFIED			CONTR. NO.		
DIMENSIONS ARE IN INCHES			DRAWN	RWJ	4-18-66
TOLERANCES ON			CHECK		
DECIMALS ± .010	ANGLES ± 0° 30'		APPR		4/18/66
FRACTIONS ± 1/32			RELEASE DATE	4-18-66	
MATERIAL					

	12-11		
NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY	1

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

CABLE, CONTROL
AC-DC CONVETER TO DVM

SIZE	CODE IDENT NO.	
B	03626	15004-500
SCALE	WEIGHT	SHEET

non linear
systems, inc.
DEL MAR, CALIFORNIA

www.manualsplus.com
1022407